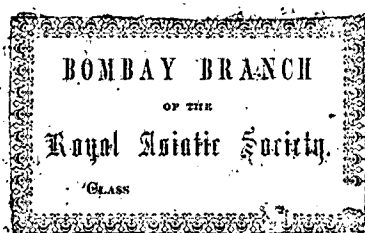




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Indian Meteorological Memoirs:

BEING

OCCASIONAL DISCUSSIONS AND COMPILATIONS OF
METEOROLOGICAL DATA

RELATING TO

INDIA AND THE NEIGHBOURING COUNTRIES.

Published by order of His Excellency the Viceroy and Governor General of India in Council.

UNDER THE DIRECTION OF

HENRY F. BLANFORD, F.R.S.,

AND

JOHN ELIOT, M.A.,

METEOROLOGICAL REPORTERS TO THE GOVERNMENT OF INDIA.

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VOL. IV.



CALCUTTA:

PRINTED BY THE SUPERINTENDENT OF GOVERNMENT PRINTING, INDIA.

1886—1893.



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INDIAN METEOROLOGICAL MEMOIRS.

I.—Account of the South-West Monsoon Storm of the 12th to the 17th of May in the Bay of Bengal and at Akyab; by JOHN ELIOT, ESQ., M.A., Meteorological Reporter to the Government of Bengal. (With Plates I and II).

THE following paper gives a brief account of the Akyab cyclone of May 1884. It is an interesting example of a class of storms of almost annual occurrence in the Bay of Bengal, *viz.*, those generated at the commencement of the south-west monsoon, on the first rush or advance of strong south-west winds from the Indian Ocean up the Bay of Bengal. When this occurs during the first half of May, the storms thus formed usually move westwards to the Coromandel Coast. The Madras cyclone of May 12th—22nd 1877¹ and that of May 18th—24th 1879² are recent examples of such storms. In this case the storms generally originate to the west or west-north-west of the Nicobars. When the south-west monsoon is later in being established, they originate further north or near the Andamans. Hence, such storms are generally formed during the last week of May or the first week of June, and they commonly move northwards or north-westwards to the Bengal or Orissa coasts; but occasionally and much more rarely, they advance to the east of north and strike the Arakan coast.

The cyclone under discussion was an example of a storm of this latter class. It moved along a track very unusual for the season, advancing in a general north-north-easterly direction to the Arakan coast.

The meteorology of the period antecedent to the storm is of some interest. The monsoon rains of 1883 terminated abruptly, and much earlier than usual in Bengal, *viz.*, in the last week of September. The rainfall over the greater part of Northern India was considerably below the normal. The cold weather months of November, December and January were unusually cool and pleasant, and the dry westerly or north-westerly winds of the Gangetic Plain and Delta much steadier than usual. A remarkable and very abnormal burst of rain accompanied the passage of a barometric depression from the south of the Bay to Bengal during the first week of December; but, with this exception, little or no rain occurred in Northern India during the cold weather months. The air was unusually dry in Northern India, more especially in Chutia Nagpur and Behar. The month of February was characterised by excessive pressure, low temperature, unusual

¹ Ind. Met. Mem., Vol. II, p. 222.

² *Idem*, Vol. II, p. 287.

dryness of the air over the whole of Northern India, and by the strength and steadiness of the land winds on the Gangetic Plains and in Chutia Nagpur. Southerly winds set in on the Bengal coast at the end of February, but, for some time, were very weak. Similar features, *vis.*, great dryness of the air, deficient rainfall, and unusually strong steady westerly winds on the Gangetic Plains, continued to characterize the month of March. The increasing action of the sun on the abnormally dry atmosphere of Northern India, however, speedily raised the temperature above the normal. Pressure, in consequence, diminished rapidly, and on the average of the whole month was considerably below the normal amount. The lowest humidity during the month at 10 A.M. was observed at Gya on the 26th, when it was only 6 per cent. The conditions which obtained in March over Northern India continued during the first fortnight of April. The temperature was considerably above the normal of the season in the whole of Bengal. Higher day temperatures were registered in Orissa and South-West Bengal, than have been recorded since the commencement of the present meteorological system of observation. The pressure was considerably below the average and the dryness of the air excessive. This culminated in three or four days of intense heat and dryness, lasting from the 12th to the 16th of April, when a great change took place. The siccidity of the atmosphere is shown most fully by the fact that, at stations so widely apart and differing so considerably in their geographical and meteorological conditions as Midnapur, Dinajpur, Dehree, Hazaribagh and Bhagalpur, on more than one occasion the humidity at 10 A.M. fell to 6 per cent. Such low humidities as these are very exceptional in Bengal, and indicate that, at this time, over a large part of Bengal, and more especially in South Behar and Chutia Nagpur, the air was almost as dry as it is in the hottest weather in the Rajputana desert, Northern Sind, or the adjacent districts of the Punjab. The increased heat and unusual dryness of the air raised the strength of the sea winds considerably above the normal, and easterly winds extended over the greater portion of Behar during the last two weeks of April. The conditions, which now prevailed, initiated a period of slight atmospheric disturbance. The barometer oscillated rapidly and unequally, and frequent thunder-storms and nor'westers occurred over the greater part of Bengal, Orissa and Behar. Rain fell, more or less abundantly, over the whole of Bengal, except Orissa, Chutia Nagpur, and a few districts in South and West Behar, which were still under the influence of dry hot westerly winds, the continuation of the winds of Upper India. This rain cooled the air, and the sea-winds, diminished considerably in strength. Dry hot weather set in again over Behar, Orissa, Chutia Nagpur, and the western districts of South-West and Northern Bengal, and lasted during the remainder of the month. Storms continued to recur at frequent intervals over the greater part of Eastern and Northern Bengal, and at longer intervals in South-Western Bengal. This change in the general character of the weather dates from the 12th and 13th, and was almost coincident with the incipient formation of the storm under discussion. The relations between the two are evident.

DETAILED HISTORY OF THE STORM.

11th May.—The following table gives the 10 A.M. values of the elements of meteorological observations of the 11th May at the stations on the coasts of the Bay, and at some of the more important observatories in the interior of India, and illustrates the

meteorological conditions which obtained immediately before the commencement of the storm :—

STATIONS.	Barometer at 10 A.M., reduced to sea-level.	Difference from nor- mal.	Tempera- ture mean of maxi- mum and minimum.	Difference from mean tempera- ture.	Humidity at 10 A.M.	Difference from nor- mal.	WIND.		
							Direction at 10 A.M.	Velocity in miles per hour for preced- ing 24 hours.	Ratio of amount of wind to average amount expressed as a per- centage.
Nancowry	29.904	0	88.1	+7.0	67	-19	SE	2	31
Port Blair	.881	+0.16	85.9	+4.7	76	-5	SE	5	63
Rangoon	.885	+0.28	90.8	+8.3	56	-17	S	6	120
Akyab	.870	+0.48	83.2	-1.0	78	+4	E	2	59
Chittagong	29.855	+0.44	80.0	-2.4	76	+2	SSE	6	93
Dacca	.817	+0.44	79.5	-3.8	73	-2	S	6	97
Calcutta (Alipur)	.828	+0.04	79.0	-5.6	92	+23	W	7	100
Saugor Island	.830	+0.83	79.2	-6.4	79	+3	SW	15	103
False Point	.817	+0.56	83.0	-2.6	61	-16	WSW	15	125
Vizagapatam	.847	+0.76	86.2	-1.6	63	-2	W	5	125
Madras	.865	+0.64	86.5	-0.9	69	+16	SSE	5	53
Negapatam	.852	+0.27	84.8	-1.1	73	+15	S	1	13
Colombo	.880	-0.15	82.0	-0.9	72	-7	SSW	6	75
Galle	.893	+0.14	80.0	-1.9	91	?	NW	6	75
Bombay	.915	+0.61	84.5	-0.5	70	+2	W	7	68
Nagpur	.793	+0.91	94.2	+1.3	30	+5	Calm	5	79
Lahore	.717	+0.68	86.5	-2.2	46	+16	E	2	61
Peshawar	.707	+0.52	84.2	+3.0	33	-1	E	5	106
Allahabad	.741	+0.55	87.8	-4.3	54	+19	E	3	88
Patna	.795	+0.88	81.0	-7.4	57	+8	E	7	156

The meteorological conditions of the first fortnight of May, over the whole of Northern and Central India, were those which precede and initiate the change called the setting in of the south-west monsoon. The hot weather conditions of Northern India were more intensely developed than usual. The low lands of Bengal, interposed between the Bay of Bengal and the parched plains of the interior, and fenced in to the north and east by lofty mountains, experienced a rapid succession of local storms; in some cases of unusual intensity. These were doubtless mainly due to the local sea winds blowing from the head of the Bay, which were either rapidly forced up by the hills of north and east Bengal, or more slowly tilted up by the Chutia Nagpur Plateau, and the strong westerly winds blowing across it from Upper India. The chief peculiarities in the distribution of pressure at this time, so far as can be judged from the present methods of dealing with the observations were,—

1st.—Pressure was relatively low over Assam, Bengal, Behar, Orissa, Chutia Nagpur and the North-West Provinces. The deficiency was greatest in a belt of country stretching from the Orissa coast through Chutia Nagpur into the North-Western Provinces. The deficiency was least marked in March, and gradually increased in amount during the months of April and May. As an atmospheric condition, therefore, it was established before the hot weather, but it was considerably intensified by the atmospheric action accompanying the increasing temperature of April and May.

2nd.—Pressure was relatively high over the whole of the Madras and Bombay Presidencies and in the Central Provinces, Burma and Arakan. The excess was small in the case of the Central Provinces and Arakan. It was large in amount in Ceylon and the extreme south of the Peninsula, including more especially the Malabar coast and Mysore, and the districts represented by the stations of Bombay, Poona and Khandwa.

Such were the more important conditions over the Indian land area immediately before the generation of the Akyab cyclone. The only marked effect of the cyclone in Northern India was the decrease of the force of the local sea breezes at the head of the Bay and in Bengal, during its existence and for a short period afterwards. This was accompanied by a diminished frequency in the occurrence of thunder-storms in Bengal and by decreased rainfall.

The history of the cyclone commences with the 12th of May. On the 11th there were no indication of the existence of a barometric depression or of unsettled weather in any part of the Bay, any where north of a line running from the south coast of Ceylon to the north of Sumatra, and almost coincident with the sixth parallel of north latitude.

The meteorology of India at this time, *i.e.*, on the 11th, was approximately normal. Pressure differed but slightly from the average, and was in excess, by amounts which increased northwards and westwards from the coasts of Madras and Bengal to the Punjab, Sind and the Bombay coast. The highest pressures on the 11th, as reduced to sea-level, were 29.918" at Bombay and 29.880" at Rangoon and Colombo, and the lowest, 29.707" at Peshawar: thus giving a difference of pressure of two-tenths of an inch, between the western and southern coast lines and the northern districts of the Empire. Temperature at this time also differed very little from the normal, as it had been reduced by the numerous storms and showers of the previous three weeks. The Central Provinces and the adjacent districts of the Bombay Presidency and Central India were the seat of the highest temperature. On the 11th the maximum day temperature, in this area, ranged between 100° and 106°. The winds on the Bengal coast were blowing rather strongly from the south-west, and on the Madras coast from directions between south-south-east and south-south-west. On the west coast of Bombay, westerly or south-westerly winds generally prevailed, and were considerably stronger than the normal winds of the season; more especially on the coast of Sind and Guzerat. The winds on the coast belt were in all cases local sea breezes, extending to some distance inland and seawards. In Northern India, the increased force of the sea winds was shown by the extension of easterly winds over Behar into the eastern and central districts of the North-Western Provinces.

The weather had been slightly disturbed for some days previously. The barometer during this period oscillated irregularly and rapidly, and frequent thunder-storms, nor'-westers and dust-storms occurred over the greater part of Northern India. As is usual in May, they were most frequent in Bengal, which had in consequence received moderately heavy and fairly general rain during the previous fortnight. The weather was somewhat more settled than on the 10th and dust and thunder-storms less frequent.

The characteristics of the meteorology of the coast area of the Bay, on the 11th, were as follow:—

1st.—The distribution of pressure was approximately normal in character, decreasing gradually from south to north and from east to west. The chief noticeable feature was the

approximate uniformity of pressure over the whole area, as is shown by the following table :—

Stations on East Coast.	Barometer at 10 A.M. reduced to 15° and to sea-level.	Stations on West Coast.	Barometer at 10 A.M. reduced to 15° and to sea-level.
	Inches.		Inches.
Nancowry	29.904	Negapatam	29.852
Port Blair	88.1	Madras	86.5
Diamond Island	89.9	Vizagapatam	84.7
Akyab	87.0	False Point	81.7
Chittagong	85.5	Saugor Island	85.0
		Calcutta (Alipur)	82.8

2nd.—Temperature, although high, was also approximately uniform around the coasts. The following table gives the mean of the day, (as determined from the maximum and minimum,) and the actual 10 A.M. temperature :—

Stations on East Coast.	TEMPERATURE.		Stations on West Coast.	TEMPERATURE.	
	Mean.	10 A. M.		Mean.	10 A. M.
Nancowry	88.1	87.4	Galle	80.0	80.0
Port Blair	85.9	87.7	Negapatam	84.8	87.9
Diamond Island	84.5	85.9	Madras	86.5	89.0
Akyab	83.2	85.1	Vizagapatam	86.2	89.5
Chittagong	80.0	82.7	False Point	83.0	89.8
Dacca	79.5	82.4	Saugor Island	79.2	84.9

3rd.—The air motion was either of average strength or in excess, over the whole of the coast area; excepting the Coromandel Coast, where, as is indicated by both the Madras and Negapatam observations, it was below the normal. The following table gives the wind velocity of the 9th, 10th and 11th at the chief stations on the coasts of the Bay; including all the observatories, which can be relied on as furnishing trustworthy observations :—

	Normal air motion.	9TH.		10TH.		11TH.	
		Velocity in miles per hour.	Ratio of amount of wind to average amount expressed as a percentage.	Velocity in miles per hour.	Ratio of amount of wind to average amount expressed as a percentage.	Velocity in miles per hour.	Ratio of amount of wind to average amount expressed as a percentage.
Port Blair	8	7	88	5	63	5	63
Diamond Island	6	6	100	4	67	5	83
Akyab	3	3	100	3	100	2	67
Chittagong	7	3	43	4	57	6	86
Saugor Island	15	12	80	16	107	15	100
False Point	12	14	117	18	150	15	125
Vizagapatam	4	4	100	5	125	5	125
Madras	10	4	40	9	90	5	50
Negapatam	8	2	25	4	50	1	13

The following table gives the meteorological information relating to the Bay and to the adjacent portion of the Indian Ocean in the neighbourhood of the Equator; being extracted from the logs of the vessels, sent in by their Captains to the Meteorological Office:—

NAMES OF SHIPS.	POSITION AT NOON.		Barometer at noon corrected.	WIND AT NOON.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Udston</i>	0° 31' S.	84° 7' E.	P	W	5	Squalls and heavy rain. Heavy west swell.
<i>Kalima</i>	0° 48' S.	84° 2' E.	P	N to NE	2	Light airs and calms. Sky overcast.
<i>Belfast of Liverpool</i>	5° 3' S.	87° 6' E.	29.86	SE	3	Steady south-east winds until 7 P.M., when a squall from west-north-west passed over the vessel.
<i>Sea Nymph</i>	6° 57' S.	84° 29' E.	.87	ESE	4	Fair weather. Slight sea.
<i>Sirdhana</i>	12° 18' N.	74° 43' E.	.83	E	2	Light variable winds and clear sky.
<i>Brindisi</i>	12° 21' N.	80° 30' E.	.84	SW	1	Calms and light variable winds. Weather fine.
<i>Cathcart</i>	16° 11' N.	82° 30' E.	.83	SE	4	Sky clear. Sea rough, south-west swell.
<i>Iolanthe</i>	15° 44' N.	93° 12' E.	.88	NW to SW	2	Light variable airs. Slight cloud. Slight swell from south-south-east.
<i>Bhundara</i>	5° 45' N.	80° 45' E.	.88	SW	P	Light variable winds. Fine weather.
<i>City of Khios</i>	7° 56' N.	73° 40' E.	.89	N	3	Fine weather. Thin cloudy sky. Wind variable.
<i>Comet</i> (F. L. Vessel) ¹	20° 46' N.	87° 40' E.	.83	SSW	4	Sea smooth. Fine weather.
<i>Star</i> (F. L. Vessel) ¹	21° 00' N.	88° 12' E.	.82	SSW	3	Hazy. Slight swell from south-south-west.
<i>Meteor</i> (F. L. Vessel) ¹	21° 2' N.	88° 46' E.	.82	SW	3	Fine weather. Smooth sea.
<i>Mermaid</i> (F. L. Vessel) ¹	21° 15' N.	88° 11' E.	.83	S by W	3	Smooth sea. Fine weather.

The preceding observations show that, over the whole of the Bay, except in the immediate neighbourhood of the coasts, winds were very light and variable, the sea smooth, and the weather sultry and oppressive. The logs of the *Cathcart* and the light vessels at the head of the Bay show that, in the neighbourhood of the Bengal, Orissa and Ganjam coasts, moderate winds were blowing, and that the sea was slightly disturbed. The skies were however clear, and the weather fine. Over this part of the Bay moderate southerly winds, force 3 to 5, were blowing. It was the northward continuation of these local winds, which formed the sea breezes prevailing at that time in Bengal. The logs of the *Sirdhana* and *City of Khios* prove that the weather in the Arabian Sea, to the north of Latitude 8° N., was exactly similar in character to that which prevailed over the greater part of the Bay. The weather at Galle and Colombo, on this day, is described as fine, with passing clouds. Hence, although the amount of information is not so large as could be wished, it appears to establish completely that, over the whole of the Bay and in the neighbouring portion of the Arabian sea, the weather was fine with light variable winds and calms; and that there was no sign of the commencement of stormy weather in any part of the Bay itself.

To the south of the Bay on the other hand, in the neighbourhood of the Equator, the weather was unsettled and squally; and a disturbance was in course of development, which, by its continued advance northwards, gave rise to the cyclone under discussion.

The observations of the F. L. ships are those of 10 A.M.

The *Udston*, near the Equator, in Latitude $0^{\circ}31' N.$ and Longitude $84^{\circ}7' E.$, had westerly winds of force 5, occasional squalls and heavy rain. The *Kalima*, 20 miles further south, had light winds from the north to north-east, with calms. The sky was overcast and suggestive of the approach of bad weather.

The ship *Belfast of Liverpool*, proceeding from Liverpool to Calcutta, was approaching the Equator, after a rapid run through the region of the south-east Trades. The Captain, who is a most competent observer and has taken regular observations for the Board of Trade in England for many years, states that he had steady south-east winds and fine weather from the 3rd of May, when he was in Latitude $30^{\circ} S.$, until the afternoon of the 11th, at 7 P.M., when he was in Latitude $4^{\circ}15' S.$, and a squall from the west-north-west interrupted the steady flow of the southerly winds, which had been experienced up to that hour. It only lasted half an hour. A slight swell also set in from the north-west.

The *Sea Nymph*, about 200 miles to the south-west of the *Belfast*, had fine weather, with light to moderate winds from the east, of force varying from 2 to 4, during the whole day.

Hence it appears to be almost certain that the weather was unsettled and squally near the Equator, and that the disturbance did not extend further south than Latitude $5^{\circ} S.$ or further north than Latitude 4° or $5^{\circ} N.$, and was thus confined to a narrow belt over the Equator, immediately to the north of the region of the south-east Trades.

The disturbance was manifested by the occurrence of squalls of brief duration and apparently of limited extent. Heavy rain was also falling over some portion of the area.

The conditions over India and the adjacent seas were, therefore, at this time very simple, although strongly contrasted. In Northern India, the fierce prolonged heat of a tropical sun, radiated through an intensely dry atmosphere, was accumulating a motive power sufficient to draw the south east trade winds northwards, and thus produce that extension of them which is called the south-west monsoon. This had indeed actually commenced: strong south-westerly winds were already established several degrees north of the Equator, and were giving rain with more or less violent squalls. Between the area of intense heat in Northern India and that of advancing atmospheric disturbance and rainfall to the north of Equator, lay the Bay of Bengal, where the quiescent state of the atmosphere indicated the absence of all strong atmospheric action. The Bay was on that very account peculiarly susceptible to external action.

12th May.—The barometric changes of the previous 24 hours, in the Indian area, had been irregular, and generally small in amount. Pressure was still somewhat unsteady in North-Western and Northern India. The weather was fine and the skies clear over the whole of India, excepting in Lower Bengal, Assam, Orissa and some parts of Madras, where thunder-storms occurred during the day and gave light showers. The temperature was increasing steadily in the interior of the country. Maximum temperatures ranging between 100° and 109.5° were observed in the Central Provinces, Central India, the North-Western Provinces, and over the greater part of the Punjab. Nagpur registered the absolute maximum 109.5° . The winds were unchanged in direction, but were slightly weaker on the Bengal coast. No change of importance had occurred in the weather on the coast of the Bay. Pressure had increased slightly at the southern and fallen at the northern stations; so that the differences of pressure were slightly greater, and the gradients from south to north increased. On the south-west coast of Ceylon, the weather had changed. Th

skies were now overcast, weather gloomy, and heavy rain was falling. Colombo recorded 3·42 inches, and Galle 0·11 inch during the previous 24 hours.

The following are the results of the 10 A.M. observations at the coast stations of the Bay:—

STATIONS.	Barometer at 10 A. M. reduced to sea-level.	Difference from normal.	WIND.			Rainfall in past 24 hours.
			Direction at 10 A. M.	Velocity in miles per hour for preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry	29·840	—·064	SSE	4	62	...
Port Blair	·899	+·034	NW	5	64	...
Diamond Island	·899	+·042	W	5	83	...
Bassein	·880	+·021	WSW	5	114	...
Akyab	·866	+·044	ESE	2	·59	0·01
Chittagong	·850	+·039	S	7	100	0·03
Saugor Island	·786	+·039	SW	13	87	...
False Point	·812	+·051	NW	12	100	0·11
Vizagapatam	·830	+·059	W	6	150	...
Masulipatam	·843	+·060	WSW	10	?	...
Madras	·898	+·097	SW	6	60	...
Negapatam	·878	+·053	SW	2	25	...
Colombo	·917	+·022	SE	7	88	3·42
Galle	·914	+·035	W	7	88	0·11

And the following table gives the available information respecting the weather in the Bay on this day:—

NAMES OF SHIPS.	POSITION AT NOON.		Barometer at Noon corrected.	WIND AT NOON.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Sea Nymph</i>	4° 58' S.	84° 37' E.	29·90	ESE	5	Cloudy. Moderate sea. Fine weather.
<i>Belfast of Liverpool</i>	3° 32' S.	87° 13' E.	·87	S by E	3 to 4	Very cloudy. Showery. Heavy swell from north-west by west.
<i>Kalima</i>	2° 52' N.	84° 02' E.	?	S to SW and W	8	Violent squalls and heavy rain.
<i>Udston</i>	3° 27' N.	84° 49' E.	?	WNW	7	Hard squalls and heavy rain.
<i>City of Khios</i>	7° 09' N.	78° 08' E.	·90	SW	2 to 3	Heavy south-west swell. Cloudy sky. Squally from south-west with rain.
<i>Bhundara</i>	8° 20' N.	82° 30' E.	·87	WNW	?	Light to moderate winds. Cloudy and showery.
<i>Sirdhana</i>	8° 45' N.	76° 35' E.	·90	Variable.	1	Light variable winds. Cloudy sky with occasional showers.
<i>Brindisi</i>	At	Madras.	·88	SW	0 to 2	Calms and light winds.
<i>Iolanthe</i>	15° 57' N.	93° 00' E.	·88	W to S W.	2	Light variable airs. Slight swell from south-south-east. Light detached clouds.
<i>Cathcart</i>	17° 27' N.	85° 23' E.	·83	SE	4	Sky clear during the day. Sea rough.
<i>Comet</i> (F. L. Vessel) ¹	20° 46' N.	87° 40' E.	·79	SSW	3	Fine weather. Sea calm.
<i>Star</i> (F. L. Vessel) ¹	21° 00' N.	88° 12' E.	·78	S W	4	Hazy. Slight swell from south-south-west.
<i>Meteor</i> (F. L. Vessel) ¹	21° 2' N.	88° 46' E.	·79	SW	3	Fine weather. Smooth sea.
<i>Mermaid</i> (F. L. Vessel) ¹	21° 15' N.	88° 11' E.	·80	SW	3	Fine weather. Smooth sea.

¹ The observations of the F. L. ships are those of 10 A. M.

The preceding observations enable the weather over and to the south of the entrance to the Bay to be approximately gauged. Strong winds had set in on the Ceylon coast, in Latitude 6° N., during the previous 24 hours, and were giving the south of the island the first burst of monsoon rainfall. The weather, near the Equator, was more unsettled and stormy than on the previous day; and the area of disturbance, as indicated by the Ceylon and other observations, was extending northwards. The *Kalima*, in Latitude 3° N. and Longitude 84° E. had dark gloomy weather, violent squalls, and heavy rain. The ship *Udston*, 50 miles further to the east, and in Latitude $3\frac{1}{2}^{\circ}$ N. at noon, had west-north-west winds of force 7 with hard squalls, heavy rain, and strong south-west swell. The *Belfast* of *Liverpool* and *Sea Nymph*, which were both to the south of Equator, furnish evidence similar to that of the preceding day. The Captain of the *Belfast* notes that the upper clouds were crossing from north to south. The sky was very cloudy, and rain fell at 2 P. M. A heavy swell from north-west by west came up during the whole of the day. The *Sea Nymph* experienced moderate south-easterly winds. The skies were clouded but the weather was fine. Thus, the observations indicate that, at the entrance of the Bay, and over a belt of about 8° or 9° to the north of the Equator, the weather was squally and unsettled, with heavy rain showers. In the Bay itself, the weather was unchanged, and winds were even feebler and more variable than on the previous day. The *Bhundara*, in Latitude $8^{\circ} 20'$ N. and Longitude $82^{\circ} 30'$ E., at noon, and advancing northwards, had light breezes and cloudy skies during the day. The *Iolanthe*, to the west of Diamond island, in Latitude $15^{\circ} 57'$ N. and longitude $93^{\circ} 0'$ E., experienced light variable airs from west or south-west, and had advanced only 20 miles in her north-west course, from Rangoon to Calcutta, during the previous 24 hours. The *Brindisi*, lying in port at Madras, had calms during the greater part of the day. Similar conditions obtained in the Arabian Sea. The *City of Khios*, in Latitude 7° N. and Longitude 78° E., began to experience squalls from south-west with rain at noon. The *Sirdhana*, further north, in Latitude $8^{\circ} 45'$ N. and Longitude $76^{\circ} 35'$ E., had light variable airs and cloudy weather during the day. Hence it is quite certain that the squally weather did not extend further north, at noon, than about 7° N., either in the Bay of Bengal or on the Arabian Sea. The first rush of south-west monsoon winds were consequently now entering the Bay and giving rise to a disturbed condition of the atmosphere near the entrance to the Bay; which was manifested by the occurrence of rain and wind squalls of limited extent. But further north, the atmospheric conditions were unchanged and the weather apparently quite settled.

13th May.—The barometer had fallen during the previous day over the whole country. Pressure, on the whole, was lowest over the Punjab and Gangetic Plains, and easterly winds were blowing over the whole of that area. In the Peninsula and Central India, there were no changes of any importance. The temperature continued to increase steadily in the interior. The eastern districts of the North-Western Provinces were now the hottest part of India. Allahabad registered the highest maximum temperature on the day, viz., $111^{\circ} 5'$.

The meteorological conditions were also unchanged over the coast area of the Bay. Pressure had decreased almost uniformly, and the baric differences between stations in the north and south of the Bay, and on the east and west coasts, were almost the same as on the 12th.

The 10 A.M. observations of the 13th, at the coast stations of the Bay, are given below:—

STATIONS.	Barometer at 10 A.M. reduced to sea-level.	Difference from normal.	WIND.			Rainfall past 24 hours.
			Direction at 10 A.M.	Velocity in miles per hour for preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry	29.860	—'044	SSW	5	77	0.16
Port Blair	848	—'017	SE	6	77	0.17
Diamond Island	846	—'011	WNW	4	66	...
Bassein	824	—'035	SSW	5	114	...
Akyab	839	+ '017	SE	2	59	0.21
Chittagong	818	+ '007	SE	5	77	1.94
Saugor Island	744	—'003	SW	13	87	...
False Point	749	—'012	SW	15	125	...
Gopalpur	762	—'003	SSW	16	107	...
Vizagapatam	774	+ '003	SW	5	125	...
Masulipatam	781	—'002	SW	9	?	...
Madras	825	+ '024	SW	6	60	...
Negapatam	805	—'020	SW	2	25	...
Colombo	876	—'019	W	9	112	0.63
Galle	862	—'017	WNW	5	62	0.38

The following table gives the meteorological information, relating to the 13th, extracted from the logs of vessels:—

NAMES OF SHIPS.	POSITION AT NOON.		Barometer at Noon corrected.	WIND AT NOON.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Sea Nymph</i>	2° 48' S.	85° 23' E.	29.89	S	4	Sky cloudy. Light showers. Moderate sea from south.
<i>Belfast of Liverpool</i>	1° 15' S.	87° 25' E.	86	S	4	Upper clouds from north-east and lower from south. Sky very watery in appearance.
<i>Kalima</i>	6° 20' N.	84° 40' E.	?	SW to NW	?	Violent squalls and constant rain.
<i>Udston</i>	7° 9' N.	85° 47' E.	?	WNW	8	Hard squalls. Heavy swell from south-west.
<i>City of Khios</i>	6° 20' N.	79° 54' E.	85	WSW	4	Moderate winds. Cloudy sky and showery weather.
<i>Bhundara</i>	11° 55' N.	83° 56' E.	81	Calm	0	Light breezes and calms. Overcast sky and fine weather.
<i>Iolanthe</i>	15° 52' N.	93° 8' E.	84	W to NE	1	Light airs and calms. Moderate swell from south-south-east. Hazy sky and sultry weather.
<i>Brindisi</i>	Left Madras for Calcutta at Noon.		83	SE	2 to 3	Sea calm. Sky clear.
<i>Cathcart</i>	18° 34' N.	86° 20' E.	80	W to SE & NW	3	Cloudy with slight haze. Rough sea.

NAMES OF SHIPS.	POSITION AT NOON.		Barometer at Noon corrected.	WIND AT NOON.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Comet</i> (F. L. Vessel) ¹	20° 46' N.	87° 40' E.	75	SW	2	Fine weather. Sea calm.
<i>Star</i> (F. L. Vessel) ¹	21° 0' N.	88° 12' E.	70	SSW	3	Cloudy and hazy. Slight swell from south-south-west.
<i>Meteor</i> F. L. Vessel ¹	21° 2' N.	88° 46' E.	75	SW by W	4	Fine weather. Slight swell from south-south-west.
<i>Mermaid</i> (F. L. Vessel) ¹	21° 15' N.	88° 11' E.	76	SW	3	Moderate sea. Fine weather.

The preceding observations generally indicate that the conditions established on the 12th continued during the next 24 hours; with, however, the important exception that, the area of strong south-westerly winds, squalls and heavy rain had extended northwards. Its northern limit at noon was, so far as can be judged from the observations, in Latitude 9° or 10° N. The winds in the expanding storm area were increasing in strength, the squalls becoming more frequent and severe, and the rainfall more continuous and intense. For example, the *Udston*, in Latitude 7° N. and Longitude 85° 47' E., had hard squalls during the day. The sky was covered with very dense clouds, and a heavy swell from the south-west passed the vessel. The *Kalima*, in Latitude 6° 20' N. and Longitude 84° 40' E., experienced violent squalls and constant rain during the day. The Captain notes that the rain clouds came up from the south with great rapidity. The *Sea Nymph*, in Latitude 2° 48' S. and Longitude 85° 23' E., had moderate southerly winds (force 4) with clouded skies and light rain.

Beyond the storm area to the north, were the *Brindisi*, which had left Madras in the morning with a calm sea, clear sky, and light variable winds; and the *Bhundara* in Latitude 11° 55' N. and Longitude 83° 56' E. at noon, which experienced light variable airs, fine weather, and overcast skies during the day. The *Iolanthe*, off the West Burma coast, had advanced only about 10 miles in her passage to Calcutta during the previous 24 hours. She had light variable airs from west to north-east, with frequent calms. The atmosphere was hazy, and weather very sultry.

Hence, the only important change of the preceding 24 hours, disclosed by the observations, was the extension of the area of strong winds and atmospheric disturbance northwards, and probably, so far as can be judged, a slight increase in the severity of the squalls, over the area of disturbance, from the Equator northwards. There was also a slight tendency to a decrease of pressure, chiefly over the northern portion of the area. This was indicated by the gradual equalization of pressure over the south and north of the Bay. For some weeks previously, there had been a slight excess of pressure over the south of the Bay as compared with the north.

14th May.—(See chart of day, Plate I). The barometer continued to fall over the whole of India; but the changes in Northern and Central India were unaccompanied by any important variation in the weather. The easterly winds, which had been blowing up the Gangetic Plains for some days, had given way during the previous 24 hours, and had been replaced by hot dry westerly winds, which were already blowing with some force. They prevailed as far east as Benares, and were continued across South Behar and Chutia Nagpur. The temperature showed a further increase. Maximum temperatures in the shade slightly exceeding 110°, were registered on this day at a large number of stations, including Nagpur, Allahabad, Gya, Hazaribagh, Akola, Jacobabad, Rajkot and

¹ The observations of the F. L. ships are those of 10 A.M.

Deesa. The highest was 114° at Jacobabad. The sky was clear over the whole of Northern and Central India; but was cloudy over the coast districts of the Peninsula, and to a smaller extent in Lower Bengal.

Over the coast area of the Bay, the relative distribution of pressure was almost unchanged, as is shown by the following observations taken at 10 A. M. :—

STATIONS.	Barometer at 10 A.M. reduced to sea-level.	Difference from normal.	WIND.			Rainfall in past 24 hours.
			Direction at 10 A.M.	Velocity in miles per hour for preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry	29.806	—'098	SSW	11	169	0.87
Port Blair	745	—'120	SSE	17	218	0.88
Diamond Island	832	—'025	SSE	5	83	0.07
Bassein	808	—'051	S	4	91	...
Akyab	814	—'008	S	2	59	0.59
Chittagong	780	—'031	SSE	5	71	0.05
Saugor Island	716	—'031	S	15	100	...
False Point	730	—'031	SW	16	133	...
Gopalpur	688	—'077	S	8	53	...
Vizagapatam	713	—'058	W	5	125	...
Masulipatam	711	—'072	SSW	10	?	...
Madras	762	—'039	WNW	7	70	...
Negapatam	775	—'050	W	3	38	...
Colombo	853	—'042	WSW	14	175	3.59
Galle	854	—'025	WNW	10	125	0.48

The only important change in the distribution of pressure, indicated by the coast observations, was a large local fall of the barometer at Port Blair and Nancowry, which, in conjunction with the changes in the wind direction and force, indicated that a barometric depression of moderate intensity had been established to the west of the Andamans during the previous 24 hours.

The same actions, which had given dry westerly winds to Northern India, had increased the force of the south-west sea breezes blowing across the Bengal and Orissa coasts. The wind directions, from Vizagapatam southwards, had shifted considerably during the previous 24 hours, and were now between West and North-West. Very strong south-west winds were blowing on the Ceylon coast, and continued to give heavy rain. Colombo received 3.59 inches during the previous 24 hours and Galle .48 inch.

Hence, the land observations indicate clearly that a depression had formed in the Bay between the Andamans and the Madras coast, and that it was being fed and maintained by a very strong humid current from the South-West. It had already influenced the air motion, as far north as Diamond Island and Vizagapatam. Further north, the winds were such as ordinarily obtain in the month of May, and were slightly stronger than the normal. The air circulation in Bengal and at the head of the Bay was evidently due to the rapid increase of temperature in the interior, which had taken place from the 11th.

The meteorological information, relating to the Bay, extracted from the logs, is given in brief in the following table :—

NAMES OF SHIPS.	POSITION AT NOON.		Barometer at noon corrected.	WIND AT NOON.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Sea Nymph</i> . . .	0° 42' S.	85° 43' E.	29.85	SSW	4	Squally with rain.
<i>Belfast of Liverpool</i> . . .	1° 10' N.	88° 31' E.	.80	SW by S	4	Dark gloomy weather. Hard squalls at 9-30. Wind increasing. Heavy swell.
<i>Kalima</i> . . .	8° 32' N.	84° 33' E.	?	S to NW	?	Violent squalls. Constant rain.
<i>Udston</i> . . .	10° 0' N.	86° 49' E.	?	NW	9	Violent squalls. High sea.
<i>Sirdhana</i> . . .	7° 9' N.	82° 10' E.	.76	Variable	1	Light variable airs. Overcast.
<i>City of Khios</i> . . .	8° 19' N.	82° 40' E.	.79	W	2	Dull cloudy weather. Showery.
<i>Bhundara</i> . . .	15° 46' N.	84° 45' E.	.73	W	?	Light variable breezes and fine weather.
<i>Brindisi</i> . . .	16° 1' N.	83° 21' E.	.74	SE	4	Sea calm. Sky clear.
<i>Iolanthe</i> . . .	16° 27' N.	92° 06' E.	.77	ESE	3	Increasing swell from south-east. Hazy.
<i>Cathcart</i> . . .	20° 33' N.	87° 20' E.	.73	SE	4	Dull cloudy weather. Sea rough.
<i>Comet</i> (F. L. Vessel) ¹ . . .	20° 46' N.	87° 40' E.	.73	SSW	3	Fine. Sea calm.
<i>Star</i> (F. L. Vessel) ¹ . . .	21° 00' N.	88° 12' E.	.71	SSW	3	Hazy. Slight swell from south-south-west.
<i>Meteor</i> (F. L. Vessel) ¹ . . .	21° 2' N.	88° 46' E.	.73	SW by S	4	Fine. Slight swell from south-south-west.
<i>Mermaid</i> (F. L. Vessel) ¹ . . .	21° 15' N.	88° 11' E.	.73	S	3	Sea moderate to rough. Fine weather.

There are strong reasons for the inference that, although rain squalls and unsettled weather may occur at or near the Equator in the Indian, Atlantic and Pacific Oceans, yet one of the conditions necessary for the rapid accumulation of energy and cyclonic motion, necessary to give rise to an extensive barometric depression and storm, is permanently absent over a narrow belt extending some degrees to north and south of the Equator. This inference is confirmed by prolonged experience of the meteorology of the Equatorial region, to which no cyclone has yet been traced. The disturbance, we are now considering, had originated in this belt; and had hitherto given rise to squalls of considerable intensity, but of very limited extent, and to unsettled weather. It had now advanced northwards beyond this belt, and entered that part of the Bay where, with favouring circumstances, the rapid condensation of aqueous vapour on a large scale, over a limited area, might and did give rise to a barometric depression and strong cyclonic circulation over a considerable area. The observations establish the fact that squally weather had not only continued, and, becoming intensified, had extended northwards, but that a well marked depression was now established. The barometers, on board the *Udston* and *Kalima*, had fallen a tenth of an inch, almost exactly the same amount as at Port Blair.

The observations, when charted, indicate that the centre of depression was in about Latitude 11° N. and Longitude 89½° E. The winds, to the north, were drawing round and blowing towards the depression; but they were very feeble, except in the

¹ The observations of the F. L. ships are those of 10 A.M.

immediate front of the advancing disturbance. The rapid increase in the force of the winds, and also the northward extension of the storm area, is shown very clearly by the Port Blair wind returns. Previously to the 12th, the amount of wind during 24 hours, as registered by the anemometer, had never exceeded 100 miles since the beginning of May. A slight increase was shown on the 13th. During the next 24 hours, when the storm was advancing to the north beyond the Latitude of Port Blair, 338 miles of wind were registered.

The *Udston* was in Latitude 10° N. and Longitude $86^{\circ} 49'$ E., 200 miles to the south-west of the central barometric depression at noon; violent squalls passed over her during the day. The *Kalima*, in Latitude $8^{\circ} 32'$ N. and longitude $84^{\circ} 33'$ E., experienced very severe squalls, increasing in violence, and with constant rain. The *Belfast of Liverpool*, in Latitude 1° N. and Longitude $88^{\circ} 31'$ E., had a hard squall in the morning, and winds increasing in force in the afternoon; and the *Sea Nymph*, which crossed the Equator northwards during the day, had moderate squalls with occasional rain showers.

These facts clearly show that no improvement had taken place in the weather at the entrance of the Bay; and that the stormy weather had extended northwards without altering its character, except at and near the front of the advancing disturbance; where a barometric depression had formed, and was increasing in intensity and extent. We have now to trace out, not, as hitherto, the extension of an area of irregular disturbance, strong winds, and squally weather, but the progress of an area of barometric depression and cyclonic circulation, increasing in intensity.

The observations also show that, at noon of the 14th, the air motion over the Bay, to the north of the central depression, was influenced as far as about Latitude 15° or 16° N. Further north, winds were generally normal in direction, but very light and unsteady. The *Iolanthe*, in Latitude $16^{\circ} 27'$ N. and Longitude 92° E., had light to moderate east-south-east winds; the *Brindisi*, in Latitude 16° N. and Longitude $83^{\circ} 21'$ E., variable winds during the whole of the day, with a calm sea and clear sky; and the *Bhundara*, in Latitude $15^{\circ} 46'$ N. and Longitude $84^{\circ} 45'$ E., light variable breezes and fine weather. The *Iolanthe*, *Pemba*, *Purulia* and *Madras*, which were all near the Burma coast, had light breezes and cloudy weather. The contrast between the winds and weather in the Bay, to the south of Latitude 12° N. and to the north of Latitude 16° N., is very striking.

15th May.—(Vide chart of day, Plate I.) The barometer had fallen, during the previous 24 hours, over the whole of North-Western, Central and Southern India. A slight recovery of pressure had taken place in Arakan, Assam, and at one or two stations in Bengal. The relative distribution over the land area, except South Burma, was generally unchanged. A large area of low pressure lay over the North-Western and Central Provinces. The wind directions in the Punjab and North-West Provinces were westerly and in Northern Bengal easterly. Strong southerly winds had prevailed for some weeks on the Bengal coast, but they were now shifting round from south through east. In Western India, the wind was steady and strong from the west. The sky was cloudy or overcast in Lower Bengal, Arakan and the west coast of the Peninsula. Elsewhere, it was clear. Rain fell during the day in Assam and Eastern Bengal. Temperature was highest over the same area as on the 14th. Maximum temperatures exceeding 110° were registered at Deesa, Agra, Allahabad, Jhansi, Benares, Gya, Nagpur, Hoshangabad,

Akola, Amraoti, Rajkot and Hyderabad. Hyderabad registered the absolute maximum (115°).

The following gives the more important 10 A.M. observations, taken at the coast stations on the 15th:—

STATIONS.	Barometer at 10 A.M. reduced to sea-level.	Difference from normal.	WIND.			Rainfall in past 24 hours.
			Direction at 10 A.M.	Velocity in miles per hour for preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Colombo	29.887	—008	WSW	19	241	0.13
Negapatam	738*	—067	W	5	65	...
Madras	703	—098	WNW	8	84	...
Masulipatam	634	—149	SE	3	...	...
Vizagapatam	688	—083	S	4	203	...
Gopalpur	703	—062	SSE	16	106	...
False Point	708	—053	SSE	14	118	...
Saugor Island	712	—035	SSE	19	131	...
Chittagong	757	—054	SSE	7	108	...
Akyab	764	—058	SE	2	59	...
Bassein	767	—092	ESE	6	136	0.68
Diamond Island	718	—139	SE	22	349	0.18
Port Blair	654	—211	SSE	14	179	1.10
Nancowry	859	—045	SSW	13	200	...

The information respecting the weather in the Bay, extracted from the logs of vessels, is given below:—

NAMES OF SHIPS.	POSITION AT NOON.		Barometer at Noon corrected.	WIND AT NOON.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Sea Nymph</i>	2° 34' N.	86° 15' E.	29.83	W by S	7	Rough sea. Weather very hazy.
<i>Traveller</i>	3° 33' N.	83° 14' E.	82	SW	7	Heavy sea. Hazy weather with heavy clouds and vivid lightning.
<i>Belfast of Liverpool</i>	3° 49' N.	88° 33' E.	79	SW by W	8	Much lightning in early morning. Huge seas from west and west-south-west.
<i>Sirdhana</i>	10° 00' N.	83° 33' E.	72	SW by W	6	Hard breeze. Rising sea.
<i>Kalima</i>	11° 00' N.	85° 50' E.	?	S to NW	?	Frequent squalls blowing with great force and calms between. Heavy north-west swell.
<i>Udston</i>	11° 18' N.	87° 29' E.	?	WNW to SW	11	Terrific squalls. Heavy forked lightning. High cross sea. Clouds moving in all directions.
<i>Pemba</i>	15° 33' N.	94° 16' E.	70	SE by E	6	Overcast and rainy. Heavy sea. Strong gale at midnight.
<i>City of Khios</i>	12° 28' N.	84° 34' E.	69	WSW	3 to 4	Overcast sky. Fair weather. Moderate sea.
<i>Iolanthe</i>	17° 20' N.	89° 55' E.	66	ESE	5	Wind steady. High sea. Weather very threatening.

NAMES OF SHIPS.	POSITION AT NOON.		Barometer at noon corrected.	WIND AT NOON.		Weather during the day.
	Latitude.	Longitude.		DIRECTION.	Force.	
<i>Brivadi</i>	18° 58' N.	86° 17' E.	29.70	E	4	Fine clear weather. Sea calm.
<i>Bhundara</i>	19° 16' N.	85° 55' E.	60	E	2	Light airs and hazy.
<i>Comet</i> (F. L. Vessel) ¹	20° 46' N.	87° 40' E.	70	S	1	Fine weather. Heavy cross swell from south-east.
<i>Star</i> (F. L. Vessel) ¹	21° 00' N.	88° 12' E.	71	SSE	2	Sea smooth. Hazy weather.
<i>Meteor</i> (F. L. Vessel) ¹	21° 2' N.	88° 46' E.	71	S by E	4	Sea smooth. Fine weather.
<i>Mermaid</i> (F. L. Vessel) ¹	21° 15' N.	88° 11' E.	76	SSE	3	Sea rough to moderate. Fine weather.

The observations of the 15th May show that the cyclonic circulation increased very rapidly in intensity during that day. This was apparently due to the rainfall that accompanied it, which was not only very heavy, indeed torrential in character, but was chiefly restricted to the area of depression proper. Hardly any rain fell at Nancowry, Port Blair, or Diamond Island during the storm; a strong proof that the rainfall was localised and concentrated. As rainfall supplied the motive power which started, increased and maintained the circulation, it is evident that, to produce the largest effect in the shortest time, the motive power must be supplied in abundance, and be applied efficiently and without waste; therefore also at the proper place. The condensation theory indicates clearly that this condition is fulfilled, when the rain, in excessive amounts, falls over the central area and is restricted to its neighbourhood. Such appears to have been approximately the case in the present cyclone. Torrential rain fell over the central area of strong cyclonic circulation; and but little fell outside of this area, except in the southern quadrant. The charted observations indicate that the centre of the barometric depression and strong cyclonic circulation was considerably further to the north than on the 14th. It was in about Latitude 13° N. and Longitude 90° E. at noon, so that it had advanced about 150 miles during the previous 24 hours. Strong winds had now extended over the east of the Bay, to Latitude 17° or 18° N. The anemometric observations at Diamond Island, near Cape Negrais, are very instructive. The anemometer, at that station, registered 88 miles of wind during the 24 hours preceding 4 P.M. of the 13th, 185 miles for a similar period on the 14th, and 650 miles on the 15th. The average amount of wind registered daily by the anemometer at that station, in June, is 230 miles. This is another illustration of the striking increase of wind that accompanied the advance of the south-west monsoon up the Bay. The weather, in the storm area proper and its immediate neighbourhood, in briefly described in the logs of the *Udston*, *Kalima* and *City of Khios*. The *Udston* was in Latitude 11° 18' N. and Longitude 87° 29' E., and about 200 miles to the south-west of the centre at noon. Frequent terrific squalls passed over the vessel. The winds varied between west-north-west and south-west in direction, as the storm advanced northwards, and were of force 10 and 11. She had a very high cross sea during the day. The *Kalima* was about 100 miles further west, and nearly 300 miles to the west-south-west of the centre, in Latitude 11° N. and Longitude 85° 50' E.: she encountered frequent heavy squalls, with intervals of calm, and was hence probably on the margin or in the outer portion of the storm area. The winds backed from north-west to south during the day.

¹ The observations of the F. L. ships are those of 10 A. M.

The *City of Khios* was almost due west of the centre at noon, at a distance of 350 miles, and was steaming north at a rate of movement slightly exceeding that of the storm. She had light westerly to northerly winds during the day, of very moderate force (4 to 1), fair weather and a moderate sea. She was thus just outside the storm area.

The weather over the Bay, to the south of the central depression, was unchanged. The *Belfast*, in Latitude 4° N. and Longitude $83^{\circ} 33'$ E. at noon, had strong south-west winds, of force 8; the *Traveller*, in Latitude $3\frac{1}{2}^{\circ}$ N. and Longitude $83^{\circ} 14'$ E., and the *Sea Nymph*, in Latitude $2\frac{1}{2}^{\circ}$ N. and Longitude $86^{\circ} 15'$ E., winds of force 7. The *Pemba* which left Rangoon for Calingapatam, and had therefore to cross the centre of the Bay, experienced southerly winds of force 6, in the Martaban Gulf. They increased rapidly in force at night, when she entered the Bay and were blowing a strong gale at midnight.

On the other hand, at moderate distances to the north and west, the weather was quite different. The *Brindisi* and *Bhundara*, off the Orissa coast, had calms and a smooth sea. The weather, in the northern and western outer quadrants of the disturbance, thus stands in remarkable contrast to that in the outer portions of the easterly and southerly quadrants.

From the above, it is not difficult to trace the changes which probably occurred during the day. Strong humid winds prevailed, during the whole day, over the Bay, to south of Latitude 16° N. and to east of Longitude 86° E., and down to the Equator. Over the southern portion of this region they gave rise to occasional squalls of considerable intensity, and further north, they fed a cyclonic circulation with vast supplies of aqueous vapour, which gave excessive rain over the central area and increased the barometric depression and cyclonic circulation rapidly during the day. Moreover, under the pressure of the strong winds of the southern quadrant, the cyclonic disturbance was advancing steadily northwards, with a slowly increasing velocity.

16th May.—(Vide chart of day, Plate I.)—During the previous 24 hours, pressure increased over the whole of India excepting Lower Bengal and Arakan, and at two or three stations of the Peninsula. Winds were variable or light in North-Western India, steady from west on the Bombay coast, and light from south and south-east at the head of the Bay and in Bengal. Maximum temperatures in the shade, exceeding 110° , were registered at Nagpur, Allahabad, Agra, Roorkee, Delhi, Akola, Amraoti, Jeypur and Jacobabad. The highest reading of the maximum thermometer was $113^{\circ} 5'$ at Nagpur. The weather was fine and skies clear, excepting in the south of the Peninsula, Burma, Arakan and the more southern districts of Bengal.

The following table gives the 10 A.M. observations at the observing stations in the Bay area:—

STATIONS.	Barometer at 10 A.M. reduced to sea-level.	Difference from normal.	WINDS.			Rainfall in past 24 hours.
			Direction at 10 A.M.	Velocity in miles per hour for preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Colombo	29.887	—0.08	SW	19	241	0.18
Galle	.888	+0.09	W	11	138	0.96
Negapatam	.762	—0.63	W	5	65	...
Madras	.734	—0.67	W	7	74	...

STATIONS.	Barometer at 10 A.M. reduced to sea level.	Difference from normal.	WINDS.			Rainfall in past 24 hours.
			Direction at 10 A.M.	Velocity in miles per hour for preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Masulipatam	29.654	—129	ESE	13	?	...
Vizagapatam	681.	—890	E	4	103	0.60
Gopalpur	.699	—066	SE	7	47	...
False Point	.679	—082	SE	8	67	...
Saugor Island	.706	—041	SSE	14	97	...
Chittagong	.737	—074	NE	3	46	...
Akyab	.729	—093	E	4	118	0.01
Bassein	.694	—165	ESB	12	273	1.34
Diamond Island	.620	—237	ESE	35	556	1.28
Port Blair	.660	—205	SSW	19	244	0.17
Nancowry	.825	—079	SW	18	277	0.80

The following is a brief abstract of the meteorological information, relating to the weather in the Bay on the 16th, given in the logs of vessels:—

NAMES OF SHIPS.	POSITION AT NOON.		Barometer at Noon corrected.	WIND AT NOON.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Sea Nymph</i>	4° 51' N.	86° 00' E.	29.85	WSW	6 to 5	Fine weather. Cloudy and hazy. High sea.
<i>Belfast of Liverpool</i>	5° 45' N.	87° 37' E.	.77	SW by W	7 to 8	Fine weather. Rather hazy. Very large sea running.
<i>Traveller</i>	7° 20' N (D.R.)	83° 44' E. (D.R.)	.75	WSW	6	Weather dull and gloomy. Heavy sea. Much lightning.
<i>Udston</i>	11° 54' N.	87° 3' E.	?	WNW to SW.	10 to 12	Winds blew from all points of compass twice since noon of 15th with terrific force. Very high confused sea. Heavy rain, incessant lightning.
<i>Kalima</i>	14° 22' N.	82° 42' E.	?	NNW	?	Squalls decreasing in force. Fine weather and light winds at night.
<i>Sirdhana</i>	13° 24' N.	85° 08' E.	.70	W	4	Moderate breeze. Cloudy and hazy.
<i>Clan Mackintosh</i>	15° 11' N.	82° 20' E.	?	?	?	Air moist and hot. Light winds. Overcast.
<i>Purulia</i>	16° 18' N.	96° 16' E.	.80	SSE	4	Fresh winds and squally during the morning. Fresh gale with very heavy south-east sea in the afternoon.
<i>City of Khios</i>	16° 46' N. (D.R.)	86° 10' E. (D.R.)	.68	N	2	Smooth sea. Cloudy. Fine weather. Light north-east swell.
<i>Pemba</i>	17° 10' N.	91° 17' E.	.45	ENE	10	Strong gale. Furious squalls after noon. 8 P.M. to midnight blowing a hurricane with high confused sea and blinding rain.
<i>Rajputana</i>	(At 5-30 P.M.) 18° 55' N.	(At 5-30 P.M.) 90° 12' E.	.58	ESE	?	Strong winds increasing to hard gale with heavy squalls.
<i>Iolanthe</i>	19° 58' N.	88° 31' E.	.66	ENE	3	Moderate winds. Heavy sea from south-east. Thick yellow haze, giving a peculiar glaze to the light.
<i>Comet</i> (F. L. Vessel) ¹	20° 46' N.	87° 40' E.	.71 (At 10 A.M.)	NE	2	Fine weather. Heavy cross swell from south-east.
<i>Star</i> (F. L. Vessel) ¹	21° 00' N.	88° 12' E.	.70 (At 10 A.M.)	Calm.	0	Fine weather. Swell from east-south east.
<i>Meteor</i> (F. L. Vessel) ¹	21° 2' N.	88° 46' E.	.70 (At 10 A.M.)	ESE	3	Fine weather. Swell increasing.
<i>Mermaid</i> (F. L. Vessel) ¹	21° 15' N.	88° 11' E.	.69 (At 10 A.M.)	SE	3	Fine weather. Sea smooth.

¹ The observations of the F. L. ships and those of 10 A.M.

The observations of the 16th show that there was now a large barometric depression in the Bay, over which the air was in violent motion. The 10 A. M. observations of the light vessels and the coast stations of Bengal and Orissa prove that the storm area had not yet extended so far north. Southerly winds, approximately normal in direction, but lighter than usual, were blowing at False Point and Saugor Island; and the weather was fine with passing clouds and the sea slight. The wind had shifted to north-east at Chittagong, so that the area of indraught had extended northwards along the east coast, and now included that station. At Akyab, the winds had backed from south-east to east with the northward advance of the depression, and were very light. The sky was overcast, and light drizzling rain was falling. The strong winds, which had been advancing steadily northwards during the previous three days, and had reached Diamond Island on the 14th, had therefore not yet extended to Akyab, which was still in the outer northern quadrant of light winds.

The information in the second table indicates that, the actions, which gave rise to the large barometric depression and cyclonic circulation on the 14th continued with increasing intensity, and produced a larger and accumulating effect on the 15th and morning of the 16th; so that, on the afternoon or evening of the 16th, a small but very violent cyclonic storm was raging in the centre of the Bay. The observations, when charted (*vide* Plate 3), indicate that, at noon of the 16th, the centre of the circulation was in Latitude $15^{\circ} 45'$ N. and Longitude $90^{\circ} 45'$ E., and was travelling northwards at a rate of nearly 10 miles an hour. The logs of the several vessels show that, as heretofore, strong winds with squally and stormy weather prevailed over the south and centre of the Bay of Bengal. The weather over the storm area proper and the whole of the south of the Bay was unchanged in general character. Winds were however stronger than on the 15th, the squalls more severe, and the weather generally more stormy. The *Sea Nymph*, in Latitude 5° N. and Longitude 86° E. at noon, had west-south-west winds of force 6 and 7; the *Belfast of Liverpool*, in Latitude $5^{\circ} 45'$ N. and Longitude $87^{\circ} 37'$ E. at noon, experienced south-west winds of force 7 to 8, with fine weather and a very high sea. The *Kalima*, in Latitude $14^{\circ} 22'$ N. and Longitude $82^{\circ} 41'$ E., had north-north-west winds, with squalls increasing in violence. The *Udston*, in Latitude 11° N. and Longitude $87^{\circ} 37'$ E., or in the centre of the Bay, experienced very stormy weather. The wind blew from all points of the compass, with terrific force, (varying from 10 to 12), nearly overwhelming the ship. She was at least 350 miles to the south-west of the centre. It is probable that she was involved in some small subsidiary disturbance or atmospheric whirl, in the rear of the larger disturbance.

The weather to the north of the storm area stood in marked contrast to the above. The *Iolanthe*, in Latitude 20° N. and Longitude $88\frac{1}{2}^{\circ}$ E., had light easterly winds of force 3, during the greater part of the day. She was less than 300 miles to the north-north-west of the centre. The *Bhundara*, anchored off Pooree, had light airs. A heavy swell from the south-east was the only indication of the bad weather existing in that direction. The *City of Khios*, in Latitude $16^{\circ} 46'$ N. and Longitude $86^{\circ} 16'$ E., had light north-north-west winds, of force 2, during the whole day, with cloudy skies, fine weather, and a moderate swell from the north-east. She was advancing north at about the same rate as the storm. The *Clan Mackintosh*, in Latitude $15^{\circ} 11'$ N. and Longitude $82^{\circ} 27'$ E.

also advancing northwards, at about the same rate as the storm, had very hot and sultry weather with light winds.

Hence, as had also been the case during the formation and earlier progress of the storm, the intense cyclonic circulation constituted but a small feature, in front of a much larger and expanding area, over which strong humid winds were blowing, and which was characterised by the frequent occurrence of rain squalls; especially severe near and to the south of the central depression. This larger area of diffuse disturbance had steadily extended northwards during the previous four days, and was now influencing the weather and winds over the north of the Bay; but evidently as an intruding element. The influence was not felt, to any marked extent, at distances greater than 150 to 200 miles to the north and west of the storm centre.

The path of the centre, during the afternoon of the 16th and early morning of the 17th, can be ascertained with approximate accuracy from the logs of two British Indian steamers, the *Rajputana* and *Pemba*, which are given in full in Appendix A. The former was proceeding from Calcutta to Rangoon. She passed Saugor Island on the afternoon of the 15th. The weather, at that time, was fine with light easterly winds. Her direct path lay across the front of the cyclone. As she advanced to the south, the weather quickly changed. The winds increased rapidly in force and hauled round, and the barometer at last began to fall quickly. At 11 P.M., the Captain judiciously changed the course of his vessel from south-east to south-west for some time, and passed round the cyclone in its westerly and southerly quadrants. The *Rajputana* was nearest to the centre at 4 A.M. of the 17th, when the centre bore 95 miles to the east. Her barometer, as corrected, stood at 29.20". She experienced, for some hours afterwards, a very heavy gale with terrific squalls and heavy rain. As she proceeded eastwards, to the south of the Burma coast, the weather improved rapidly.

The *Pemba* left Rangoon, on the afternoon of the 14th, for Calingapatam, on the opposite coast of the Bay. She passed the Alguada reef at noon of the 15th, and then proceeded almost due west across the Bay. This brought her directly in front of the storm, and in the line of its advance on the 16th. The weather grew rapidly worse, as she proceeded westward on the 15th. A strong gale, with heavy rain, was blowing at 7 A.M. of the 16th. The Captain then changed the course of the steamer to north, and as the weather grew rapidly worse, he eased the engines and proceeded slowly northwards. The centre of the cyclone was advancing at this time at a rate of about 10 miles, and passed the ship a few miles to the east at 2 A.M. of the 17th. The *Pemba* had strong gales with heavy seas and hard squalls before midnight. From 2 A.M., to 4 A.M., when the centre was passing to the northward, the winds blew from the north with cyclonic force, and heavy rain fell. The barometer was at its lowest at 2 A.M. when the reading, corrected for temperature, was 29.09". As the *Pemba* was at a distance of about 10 or 15 miles to the west of the centre, it is almost certain that, at the centre, the barometer was not lower than 28.9". At the time that the centre was passing the *Rajputana* and *Pemba*, on its northward course, it was beginning to curve considerably to the east. A reference to Plate II will show the positions of the *Rajputana* and *Pemba*, with respect to the centre, at different hours on the 16th and 17th.

17th May.—(Vide chart of day, Plate I.) The barometer had fallen in North-Western

and risen in Western and Southern India. A rapid decrease of pressure in Arakan and East Bengal accompanied the northward advance of the depression in the Bay. Temperature had decreased slightly during the previous 24 hours; but maximum temperatures, exceeding 110° , were registered over the same area as previously in Central and Northern India. The highest was 114° at Agra. The skies were clear in the North-Western Provinces, Central India and Behar, and the Central Provinces. They were overcast in Burma and the south of the Peninsula, and more or less clouded in the remaining provinces.

The following table gives the 10 A.M. observations, at the coast stations, for the 17th:—

STATIONS.	Barometer at 10 A.M. reduced to sea-level.	Difference from the normal.	WIND.			Rainfall in past 24 hours.
			Direction at 10 A.M.	Velocity in miles per hour for preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Colombo	29.895	0	SW	16	203	0.04
Galle	29.900	+0.021	W	11	138	0.23
Negapatam	29.777	-0.048	W	5	65	...
Madras	29.718	-0.083	W	8	84	...
Masulipatam	29.611	-0.172	NW	8	?	...
Vizagapatam	29.619	-0.152	W	3	77	...
Gopalpur	29.629	-0.136	SE	9	60	...
False Point	29.615	-0.146	NE	6	50	...
Saugor Island	29.606	-0.141	NNW	10	69	...
Chittagong	29.572	-0.239	N	2	31	...
Akyab	29.524	-0.298	E	3	88	0.16
Bassein	29.780	-0.079	S	19	432	0.61
Diamond Island	29.684	-0.173	S	32	508	0.45
Port Blair	29.773	-0.092	SW	20	256	0.42
Nancowry	29.830	-0.074	SW	8	123	0.91

The following gives the meteorological information relating to the Bay:—

NAMES OF SHIPS.	POSITION AT NOON.		Barometer at Noon corrected.	WIND AT NOON.		Weather and state of sea during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Sea Nymph</i>	7° 13' N.	85° 00' E.	29.72	SW by W	7	Strong winds. Overcast sky and hazy atmosphere. No rain.
<i>Kalima</i>	16° 8' N.	83° 34' E.	?	S to SW	?	Fine clear weather and smooth sea.
<i>Belfast of Liverpool</i>	8° 38' N.	85° 46' E.	73	SW	8	Fresh winds decreasing in force during day. Somewhat hazy.
<i>Traveller</i>	9° 4' N.	83° 20' E.	71	?	5	Very hazy atmosphere. High southerly swell.

Names of Ships.	Position at Noon.		Barometer at Noon corrected.	Wind at Noon.		Weather and state of sea during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Pembroke</i>	17° 12' N.	90° 34' E.	29° 51	WNW	6	Hurricane at 2 A.M. Weather gradually moderated during day. At midnight moderate breezes with overcast sky and heavy sea.
<i>Rajputana</i>	?	?	43	NW by W	?	Furious squalls during the morning. Heavy rain. Weather improved during the evening.
<i>Purulia</i>	14° 41' N.	95° 2' E.	81	SSW	6	Frequent very heavy squalls with much wind and rain, confused sea.
<i>Udston</i>	14° 24' N.	86° 44' E.	?	SW	9	Overcast and hazy. High cross sea.
<i>Sirdhana</i>	16° 35' N.	86° 37' E.	65	W	2	Light breeze. Sky overcast and hazy.
<i>Clare Mackintosh</i>	18° 22' N.	86° 05' E.	?	SW	?	Light airs. Sky overcast and hazy.
<i>Jolanthe</i>	20° 52' N.	88° 05' E.	59	NNE	3	Heavy north-east swell. Calms and light winds. Very heavy sea from south-east.
<i>City of Khios</i>	20° 40' N.	88° 05' E.	61	NNW	2	Heavy swell. Fine weather, cloudy. Heavy easterly swell.
<i>Comet</i> (F. L. Vessel) ¹	20° 46' N.	87° 40' E.	60	NE	1	Heavy cross swell from south-east. Cloudy.
<i>Star</i> (F. L. Vessel) ¹	21° 00' N.	88° 12' E.	59	N	2	Heavy swell from south-east. Hazy.
<i>Meteor</i> (F. L. Vessel) ¹	21° 2' N.	88° 46' E.	59	N	4	Heavy south-west swell. Weather unsettled and gloomy.
<i>Mermaid</i> (F. L. Vessel) ¹	21° 15' N.	88° 11' E.	59	N by E	3	Rough cross sea. Rain nil.

The preceding observations show that the vortex continued to move in a general northerly direction. As has been stated above, it began to curve slightly to the eastward on the afternoon of the 16th. This motion to the east of north became more marked during the 17th. At noon, so far as can be judged from the observations, the centre was approximately in Latitude 19° N. and longitude 91½° E.; so that it had advanced about 240 miles, or at the rate of 10 miles per hour. It was therefore approaching the Arakan coast nearly at right angles to the trend of the coast and of the parallel range of hills. The barometer fell rapidly at Akyab during the afternoon. At the observatory, the reading at 10 A.M. was 29° 524", and at 4 P.M. 29° 29". The anemometric observations illustrate the quiescent state of the atmosphere previously to the near approach of the cyclone; when very violent winds set in. The anemometer at the observatory, which is at some distance from the sea and in a slightly sheltered position, registered 80 miles, for the total movement of the previous 24 hours, at 4 P.M. of the 15th, 100 miles on the 16th, 200 miles on the 17th, and 440 miles for the 16 hours between 4 P.M. of the 17th and 10 A.M. of the 18th. An account of the cyclone, as experienced at Akyab, and of the destruction of the property, extracted from a report of Colonel Spearman, Deputy Commissioner of Akyab, is given in Appendix C. The strength of the winds is more accurately gauged from the destruction of property, which occurred on the Arakan coast during the night of the 17th, than from the anemometric observations at the Telegraph Office. The centre crossed the coast at Akyab about 9 P.M. of that day, at which time the barometer stood at 28° 98". There was a lull for about five minutes, after which the wind suddenly shifted to south-south-west from its former direction east-south-east; thus proving that the centre passed directly over Akyab. The disturbance was now in the immediate neighbourhood of a range of hills. Dr. Hunter describes the Arakan hills in the Akyab district as steep and

¹ The observations of the F. L. ships are those of 10 A.M.

throwing out numerous spurs. They can only be crossed by regular passes. Their height varies from 3,000 to 4,000 feet. The loftiest peak, Blue Mountain, is 7,100 feet above the sea-level. These hills constituted a formidable obstacle, presented to the active or influential portion of the cyclone. The accounts show that they not merely constituted an effective barrier to its further progress eastward, but that they caused the rapid disintegration of the cyclonic motion. Before 10 A.M. of the 18th, the disturbance was completely broken up. Light irregular winds and calms prevailed on the Arakan coast, while moderate south-west winds with cloudy or hazy weather obtained over nearly the whole of the Bay. The *Purulia*, which was in Latitude $16^{\circ} 29'$ N. and Longitude $93^{\circ} 32'$ E.; and proceeding to Calcutta, had fresh winds in the morning at 8 A.M., but, in the afternoon, moderate south-west winds of force 4.

The vessels which have contributed logs were now all in the southern or western quadrants of the cyclone. The weather had already improved considerably over the south of the Bay. The *Belfast of Liverpool*, in Latitude $8^{\circ} 38'$ N. and Longitude $85^{\circ} 46'$ E., at noon, had steady fresh monsoon winds, of force 7 to 8, during the day. The *Sea Nymph*, in Latitude $7^{\circ} 13'$ N. and Longitude 84° E., also had steady south-west winds of force 7. The *Udston*, in Latitude $14^{\circ} 24'$ N. and Longitude $86^{\circ} 44'$ E., reports strong south-west winds in that part of the Bay, with overcast skies and a hazy atmosphere. The *Kalima*, in Latitude $16^{\circ} 8'$ N. and Longitude $83^{\circ} 34'$ E., on the other hand, had fine clear weather and a smooth sea; and the *Sirdhana*, in Latitude $16^{\circ} 35'$ N. and Longitude $86^{\circ} 37'$ E., had light westerly breezes. The weather in the Bay, to the west and north-west of the disturbance, was similar to that experienced by the *Kalima*. The *Clan Mackintosh*, in Latitude $18^{\circ} 22'$ N. and Longitude $86^{\circ} 5'$ E., had light airs; and the *Iolanthe*, in Latitude $20^{\circ} 52'$ N. and Longitude $88^{\circ} 6'$ E., calms and light north-north-east winds. The latter vessel states that she met with very strong currents, as is almost invariably the case, at the head of the Bay, during any disturbance in the Bay.

The contrast between the winds on the southerly and easterly outskirts of the disturbance and those in the north and west is thus very strongly marked. In the former, strong winds extended southwards to the neighbourhood of the Equator. In the latter, light winds and calms prevailed at distances of less than 250 miles from the centre. These facts show conclusively, that the main body of the indraught was that of the southerly humid winds advancing up the Bay.

18th May.—The meteorology of this day is given, in order to show how completely and rapidly the disturbance was disintegrated by the action of the Arakan hills.

The barometric changes were slight in all parts of India, except in East Bengal and Arakan; where a rapid rise had followed the passage of the disturbance across the coast. The general tendency of the changes was to increase pressure, to a small extent, over the empire. The temperature was slightly lower than on the previous day. The area of greatest heat, as defined by a maximum temperature of 110° and upwards, included the stations of Agra, Bareilly, Sutna, Delhi, Allahabad, Nagpur and Amraoti. The highest maximum registered was 112° , at Agra and Allahabad. The winds in Lower Bengal and on the north-west coast of the Bay had reverted to their normal direction: strong west to south sea breezes were blowing on the west coast of India. The skies were clear over the same area as on the previous day. They had become overcast in Eastern Bengal where moderate rain fell during the day.

The following table gives the observations taken at the more important coast stations of the Bay:—

STATIONS.	Barometer at 10 A.M. reduced to sea-level.	Difference from normal.	WIND.			Rainfall in past 24 hours.
			Direction at 10 A.M.	Velocity in miles per hour for preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Colombo	29.852	—043	SW	15	190	...
Negapatam	.767	—058*	SW	4	52	...
Madras	.760	—041	W	10	105	...
Masulipatam	.662	—121	WNW	10	?	...
Vizagapatam	.635	—136	W	4	103	...
Gopalpur	.605	—160	S	12	80	...
False Point	.610	—151	SW	11	92	...
Saugor Island	.612	—135	SSW	11	76	...
Chittagong	.607	—204	S	5	77	1.08
Akyab	.690	—132	SSW	23	676	6.20
Bassein	.851	—008	SSE	9	205	0.84
Diamond Island	.844	—013	S	12	190	1.41
Port Blair	.877	+012	SW	16	205	...
Nancowry	.876	—028	SSW	11	169	0.87

The following extracts from the logs of vessels give the character of the weather in the Bay on the 18th:—

NAMES OF SHIPS.	POSITION AT NOON.		Barometer at Noon corrected.	WIND AT NOON.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Sea Nymph</i>	9° 52' N.	84° 5' E.	29.80	W by S	5 to 4	Moderate winds, Hazy.
<i>Belfast of Liverpool</i>	12° 6' N.	85° 13' E.	.75	SW	7	Fresh monsoon throughout and fine weather. High south-west swell.
<i>Traveller</i>	12° 2' N.	83° 36' E.	.71	SW	6	Hot sultry weather. Moderate sea.
<i>Rajputana</i>	?	?	.67	S	?	Fresh breeze and broken sea.
<i>Purulia</i>	16° 29' N.	93° 32' E.	.87?	SW	5	Fresh wind. Moderate south-west monsoon. South-west swell.
<i>Pemba</i>	17° 33' N.	87° 2' E.	.66	SW	4	Moderate breeze and hazy. Heavy south-west swell.
<i>Kalima</i>	18° 30' N.	85° 19' E.	?	SW	?	Light winds and fine clear weather.
<i>Udston</i>	17° 43' N.	86° 58' E.	?	SW	4	Hazy and cloudy.
<i>Japan</i>	19° 41' N.	89° 6' E.	.60	SSW	3	Moderate breeze and fine.
<i>Sirdhana</i>	19° 45' N.	88° 2' E.	.66?	SW	2	Light breeze and very hazy.
<i>Comet</i> (F. L. Vessel) ¹	20° 46' N.	87° 40' E.	.61	SW	2	Heavy cross swell. Clear. Fine weather.
<i>Star</i> (F. L. Vessel) ¹	21° 00' N.	88° 12' E.	.61	SSW	2	Swell from south-south-west. Weather cloudy.
<i>Meteor</i> (F. L. Vessel) ¹	21° 2' N.	88° 46' E.	.61	SW by S	3	Heavy south-west swell. Weather unsettled looking.
<i>Mermaid</i> (F. L. Vessel) ¹	21° 15' N.	88° 11' E.	.60?	WSW	3	Sea moderate to smooth. Fine weather.

¹ The observations of the F. L. ships are those of 10 A.M.

The preceding observations prove that south-west winds of varying intensity were established over the Bay on the morning of the 18th. The cyclonic disturbance had been completely broken up and disintegrated by the resistance of the Arakan hills during the night; and, consequently, one cause of the intensity of southerly winds in the Bay had been removed; (*viz.*, the indraught to the area of depression and the ascensional motion over it). The winds were slightly less vigorous, but were unchanged in their general character over the south and centre of the Bay. The log of the *Belfast of Liverpool*, in Latitude $12^{\circ} 6' N.$ and Longitude $85^{\circ} 13' E.$, at noon, states that fresh monsoon winds of force 7 blew during the whole day. The log of the *Sea Nymph*, in Latitude $9^{\circ} 52' N.$ and Longitude $84^{\circ} 5' E.$ records that the south-westerly winds on the part of the Bay she traversed decreased from force 7 to force 4 during the day. The *Traveller*, in Latitude $12^{\circ} 2' N.$ and Longitude $83^{\circ} 36' E.$ had hot sultry weather with south-west winds, force 6. Near the head of the Bay, the winds were very much lighter. The *Kalima*, in Latitude $18^{\circ} 30' N.$ and Longitude $88^{\circ} 19' E.$, had light south-west winds and fine clear weather. The *Sirdhana*, in Latitude $19^{\circ} 45' N.$ and Longitude $88^{\circ} 2' E.$, had light south-westerly breezes, force 2, in the morning and calms or light airs during the evening and night. Thus fine weather prevailed over the whole of the Bay: moderate monsoon winds of force 5 to 7 were blowing over the south and centre of the Bay, and light south-west winds over the north of the Bay; decreasing in intensity northwards. There was a marked tendency in the force of the winds to decrease, owing, apparently, to their diminished intensity at the entrance to the Bay. This is confirmed by the observations of the 19th and 20th; on the latter of which days, light variable winds, (nowhere exceeding force 4,) were again established for a brief period over the whole of the Bay.

DISCUSSION OF THE FOREGOING DATA AND GENERAL CONCLUSIONS.

The history of the Akyab cyclone of May 1884 has been briefly given in the preceding pages. It only remains to call attention to its more prominent features and phenomena.

The facts of its generation are simple and instructive. The cold weather conditions over the Indian land area had begun to give way in February. The increasing and accumulating effect of the sun's thermal action on the atmosphere had proceeded with unusual rapidity during the months of March and April, and hot weather conditions were fully established over Central and the greater part of Northern India, during the latter of these months, in an unusually intense form. This change of conditions and of the meteorological relations between land and sea had set up and maintained a local circulation of considerable strength at the head of the Bay. It was shown, near the earth's surface, by the prevalence of southerly winds, over a small portion of the Bay, in the immediate neighbourhood of the Bengal and Orissa coasts, and over a large portion of Bengal. These winds brought up much vapour, which was condensed and precipitated as rain, during the frequent local thunder-storms, which occurred during the last fortnight of April and the first week of May. Previously to the 11th of May, the increasing heat of the interior had strengthened considerably the local sea breezes at the head of the Bay, during the months of March and April, but had not caused any general change of air motion over the Indian area. That which is the ultimate effect of the actions accompanying the hot weather, *viz.*, the setting in of the south-west monsoon, by which I designate the prolongation of the

south-east trades winds across the Equator and their advance northwards up the Bay, as south-west winds, had not been brought about. At the beginning of May, between the extensive region covered by the south-east trades and the area of local sea breezes at the head of the Bay, there lay a sea area of moderate extent, comprising nearly the whole of the Bay, in which different conditions prevailed. These are clearly indicated by the observations given in the previous discussion. Pressure decreased continuously from the south to the north of the Bay; but the rate of decrease was very small, except in the immediate neighbourhood of the Bengal and Orissa coasts, where the gradients were directly related to the strong local winds which there obtained. Over the whole of the central area of the Bay, the differences of pressure were so small as to be of little importance. This approximate uniformity of pressure was accompanied by temperature and humidity conditions almost equally uniform; by the prevalence of very light and variable winds, sultry weather and a smooth sea. The whole area of the Bay, except a small portion near the Bengal coast, was characterized by an approximate uniformity of meteorological conditions, the strongest evidence of which was the local and feeble character of the winds. These conditions had obtained for at least a fortnight previously; during which period, there was no evidence of any accumulation of energy in the potential form, which, by its conversion into kinetic energy, could explain the development of the subsequent cyclonic disturbance. The antecedent conditions were similar in character to those, which cyclone research has shown to be present before all the larger storms in the Bay of Bengal. It may be added that the air motion, as indicated by the wind direction at the coast stations, considered as a whole, was anticyclonic rather than cyclonic in its character, and such as would almost certainly accompany the existence of somewhat higher pressure in the centre than in the north of the Bay. Winds were from south-east on the Madras coast, south-west on the Bengal coast, and north-east in Burma, and at the Andamans. There was almost certainly no area of low pressure in the Bay, prior to the disturbance which developed into the cyclone; nor, as has been already pointed out, was there, so far as can be judged, any accumulation on the large scale, of the potential energy in the atmosphere over the Bay. The immediate cause of the cyclone, that is, the increase of energy, came from without, as an intruding and disturbing element. The immediate antecedent and initial disturbing action was the entrance of strong humid southerly winds into the Bay. The information, extracted from the logs of the vessels which were in the Bay at the time, establish the fact that the south-east trades were continued as strong winds across the Equator on the 10th and 11th of May, and gradually advanced northwards. To employ ordinary language, the south-west monsoon began or burst on the Ceylon coast and at the entrance to the Bay, on the 12th May, with strong winds and heavy rain.

It may be here noted that the character of the advance of the south-west monsoon winds proper, (of which the present was an ordinary example,) appears to be completely opposed to the ordinary or convection theory, sometimes adopted to explain the origin of these winds. According to this theory, the heated interior of India acts as a furnace, the heated air rising rapidly over the interior in the hottest parts of Central and Northern India, and the air rushes in from the neighbouring districts, the action spreading outwards from the hottest area to the adjacent seas. The history of the present storm suggests an entirely different order of succession in the phenomena. Instead of the southerly

winds extending southwards from the Bengal coast, and thus drawing the air from more and more distant regions, to maintain the increasing ascensional movement over the hottest part of India, there was a large intermediate area in which the variability and lightness of the winds were such as to prove, most conclusively, that there was no indraught, of any importance, from the Bay generally to the land area, during the progress of the first burst of monsoon winds up the Bay. The monsoon winds advanced from the Equator northwards, into this calm area, as an intruding element forced into it. This advance may be directly explained by the pressure and weight of the moving mass to the south, or by the indraught to the area of rainfall which occurred mainly in front of the advancing humid winds. Probably both actions were efficient in producing the intrusion of these winds into the Bay area, wherein pressure and other meteorological conditions were approximately uniform. The primary disturbance was undoubtedly the accumulation of heat in the Indian land area; but it is evident that much more than this is necessary, to explain the actual motion of the monsoon at its commencement; and, also, it may be added, of any repetition of the same phenomenon during the south-west monsoon; such as occurs after every break in the rains in Northern India, when an onset of strong winds advances up the Bay across the Bengal coast, and carries another burst of rain into the interior.

The southerly winds, which entered the Bay on the 12th, gradually extended northwards, the circulation in the rear being maintained by the south-east trades. The appearance they presented was that of an area of strong winds expanding or extending northwards; and the front of the advancing winds was in about Latitude 7° N. at noon of the 12th, and in Latitude 9° N. on the 13th. Strong winds prevailed over the whole area to the south as far as the Equator; but throughout, they were strongest near their northern limit. There was also much irregular eddying action near the front, which was shown, so long the advancing front was to the south of Latitude 10° or 11° N., by the occurrence of squalls of limited extent; but becoming more frequent and severe with the northward extension of the area of strong winds. There was, in fact, at this period, much disturbance, similar in kind to that which occurs in the belt of calms in the Atlantic or Pacific Ocean. There was ascensional motion of an irregular kind, heavy rain showers and wind squalls; but these did not extend over any considerable area near the Equator. For example, the *Udston*, in Latitude $0^{\circ} 34'$ S. and Longitude $84^{\circ} 7'$ E., had squalls and heavy rain on the 11th. The *Kalima*, which was less than 20 miles to the west, had light airs and calms throughout the day. The Captain notes that the sky was overcast and squally in appearance. Whatever may have been the actions which produced the northward advance of the south-east trade winds, across the Equator into the Bay, there is no doubt as to the character of the motion itself. The logs of the *Belfast of Liverpool*, *Traveller*, *Sea Nymph* and other ships prove that steady south-east trades winds, with quiet settled weather, prevailed over the whole area they covered, except near the Equator. There were indications of slight disturbance in that area: on the 10th and 11th, squalls occurred with heavy local rain. The southerly winds extended northwards, and the squalls increased in severity and extent. A slight tendency to diminishing pressure was then shown in front of the advancing current. It was, however, not until the morning of the 14th, when the front was in Latitude 12° N., that there was a clearly marked area of depression, which advanced in front of the strong mass of southerly winds. It was the

development of the depression, formed in front of the advancing body of southerly winds when they passed beyond Latitude 9° or 10° N., which produced the cyclone. The history of the advance and disintegration of the vortex has been fully given in the preceding pages, and it is hence unnecessary to do more than to summarize the data giving approximately the path of the centre of the cyclone.

The path of the centre is approximately given by the following positions at the hours stated, and is shown in Plate II :—

Day.	Hr.	Position.		Distance passed over in previous 24 hours.	Rate of advance in miles per hour during previous 24 hours.
		Latitude North.	Longitude East.		
14th	Noon.	$11^{\circ} 0'$	$89^{\circ} 30'$	..	...
15th	Noon.	$13^{\circ} 0'$	$90^{\circ} 0'$	140	6
16th	Noon.	$15^{\circ} 40'$	$90^{\circ} 45'$	190	8
17th	2 A. M.	$17^{\circ} 30'$	$91^{\circ} 10'$	130	9
"	Noon.	$18^{\circ} 55'$	$91^{\circ} 45'$	105	$10\frac{1}{2}$
"	9 P. M.	$20^{\circ} 30'$	$93^{\circ} 0'$	135	15

The successive positions, assigned to the centre in the table, can be assumed as only approximately correct, since they are deduced from a small number of observations. They, however, harmonize with the whole of the barometric observations, except those taken on board the *Kalima* and *Udston*, which were so much at variance with those of the remaining vessels and the coast observatories, during the whole period, as to show that they are unreliable, and due to unknown and variable defects of the instruments used. The cyclonic vortex is shown, by the preceding statement, to have travelled in a curved path northwards and then eastwards; the easterly element of the motion increasing considerably on the 17th. Its rate of motion steadily increased, from 6 miles per hour, at which rate the monsoon winds appear to have advanced at and near the entrance to the Bay, to about 15 miles per hour, during the last nine hours of its advance at sea, and when it was approaching the Arakan coast.

Nine out of ten cyclones generated in the Bay travel to the west of north, the westerly element usually predominating. In the great majority of cases, the most intense cyclones of the Bay have originated in the centre of the Bay, and travelled almost due north over the greater part of their course. This direction, taking into consideration the one feature that all cyclonic disturbances have in common, *viz.*, that they advance *up* the Bay or have a northerly component of motion, gives the longest possible path. The selection of the longest path gives a longer time for the disturbance to accumulate energy and increase in intensity.

The causes of the deflexion to the east, in this case, are doubtful. They can apparently only be sought in two directions :—

1st.—In the antecedent meteorological conditions.

2nd.—In special conditions accompanying the cyclone.

The following table gives the data of the antecedent conditions of pressure and air-motion:—

STATIONS.	Average variation of pressure from May 5th to 11th.	Average air motion.	Percentage of actual to a average air motion.
Port Blair	—'005	4	51
Diamond Island	+ '007	6	95
Akyab	+ '028	3	88
Chittagong	+ '036	4	62
Saugor Island	+ '058	14	97
False Point	+ '031	15	126
Vizagapatam	+ '037	5	128
Madras	+ '061	7	74

This table shows that the eastern half of the Bay, as compared with the western half, had been characterized, for some days previously to the origin of the storm, by relatively deficient pressure and by comparative calm. These conditions were most marked at Port Blair, but the means for Diamond Island, Akyab and Chittagong show that they were common to the eastern half of the Bay.

The observations, taken during the storm, do not disclose any special action during the cyclone which would explain its easterly motion. The main body of strong winds was undoubtedly to the south of the disturbance; and over the whole area to the west, north, and north-east, on the outskirts of the disturbance, the winds were very light. The northward advance was evidently in part due to the pressure of the strong winds or the vast mass of moving air to the south, and also to the indraught produced by the rainfall over the advancing depression. These, as is so frequently the case in atmospheric actions, gave rise to further secondary actions, which intensified the original disturbance, and the final resulting motion was largely due to the interactions and secondary actions set up by the original motion. Hence, it appears to be probable that the easterly element of the motion was determined by antecedent meteorological conditions; the most marked of which were deficient pressure and air motion in the east of the Bay, represented by Port Blair, Arakan, and the neighbourhood. The path of motion or the path of least resistance, in many cases of the larger cyclones that have been examined, coincides, more or less exactly, (the observations being very few) with the area of least air motion (relatively to the normal): and the present case, although it does not strikingly illustrate it, appears to afford a partial confirmation of the law. It has already been pointed out that the rainfall, which accompanied the cyclone, was heavy over the area of disturbance and to the south of it, but was unusually small in amount beyond the area of disturbance to the north and west. It was not diffused, but concentrated in an unusual degree: and this explains the intensity of the disturbance. The following gives the rainfall in Burma and Bengal, from the 12th to the 18th May; and shows that Burma received moderate rain and Bengal very little

during the cyclone; much less, in fact, than it had received from the local sea winds, prior to the 12th and 15th:—

General average rainfall at Stations in Burma and Bengal from the 12th to 18th May 1884.

PROVINCES.	Number of Stations.	MAY 1884.							Total.
		12th.	13th.	14th.	15th.	16th.	17th.	18th.	
Burma	15	0'08	0'08	0'26	0'42	0'83	0'80	0'99	3'46
East Bengal	26	1'17	0'54	0'17	0'22	0'03	0'01	0'30	2'44
South-West Bengal	46	0'17	0'10	0'07	0'10	0'05	0'06	Nil.	0'55
North Bengal	28	0'02	0'03	0'46	0'63	0'49	0'38	0'00	2'01
Behar	40	0'02	0'03	0'09	0'03	0'10	0'14	Nil.	0'41
Chutia Nagpur	11	0'02	0'12	Nil.	Nil.	Nil.	Nil.	Nil.	0'14
Orissa	16	0'59	Nil.	0'05	Nil.	Nil.	Nil.	Nil.	0'64

The number of stations on the Arakan coast of the Bay, which submit registering rainfall returns to the India Meteorological Office, is very small. The following gives the whole available information respecting the rainfall of the 16th, 17th, 18th, and 19th which was due to the disturbance:—

STATIONS.	Rainfall of 16th.	Rainfall of 17th.	Rainfall of 18th.	Rainfall of 19th.	TOTAL.
Akyab	0'03	0'56	5'80	0'71	7'10
Cox's Bazar	...	...	2'36	7'16	9'52
Sandoway	0'81	2'42	0'55	1'20	4'98
Kyaukpyu	0'04	0'10	1'20	0'32	1'66

The first and most marked indications of the approach of a small cyclonic storm, in the north of the Bay, to ships traversing it, are the shifting of the winds which occurs as a vessel enters the storm area, and the strong swell or surface disturbance which spreads outwards; (the advance of which approximately coincides in direction with that of the winds). The barometer does not give marked or satisfactory indications, until the vessel is in the immediate neighbourhood of the centre. Small changes of the barometer, in the Bay of Bengal, are masked by the large regular diurnal oscillatory changes. The proper navigation of a vessel, during a cyclonic storm in the Bay, is to avoid the centre; and, except in special cases, to pass as speedily as possible to the rear of the advancing storm. Hence, it is very desirable to know the relation between the direction of the storm centre and the wind at any instant. For many reasons, this can be determined only approximately, one chief reason being that, the wind direction is somewhat variable, during the heavy squalls that frequently occur. A very accurate series of wind observations was taken on board the *Rajputana* (given in full in Appendix A). When these are considered with reference to the position of the centre at the same hours, they show that there is a nearly constant relation between the wind direction and the bearing of the centre, over the greater part of the cyclonic disturbance. It is approximately exact in the dangerous quadrants,

vis., the north-west and north-east, which are those in front of the storm, and from which it is most difficult to pass away near the head of the Bay, except in the immediate neighbourhood of the storm centre. The relation is "Face the wind exactly, and the direction of the storm centre is eleven points to the right." The rule is not applicable with the same exactness in the southern quadrants, because the strong winds in the smaller cyclones of the Bay extend to very considerable distances to the south, and beyond what may be called the limits of the cyclonic disturbance proper.

There is one other point, in connection with this disturbance, of some interest. There are several indications, in the land and sea observations, that the action, near the Equator, which gave rise to the strong advance of southerly winds, was not confined to the Bay of Bengal, but extended to the Martaban Gulf. It apparently produced similar effects there on a smaller scale; but the action in front did not give rise to a large cyclonic disturbance as in the Bay. There was, however, a rapid advance of strong southerly winds, squally and stormy weather, and much irregular action, shown by sudden and much shifting of the wind. Probably the difference in the extent of the water surface had some influence. It is, however, almost certain, on theoretical grounds, that the accumulation of action and energy, necessary to generate a cyclonic disturbance in the Bay, would be possible only in the absence of a similar action in the Gulf of Martaban. The character of the weather there, during the Akyab cyclone, is sufficiently illustrated by the fact that the B. I. S. *Madras*, which left Rangoon on the morning of the 16th, experienced such rough weather during the evening of the 16th and morning of the 17th, as to be compelled to return to that port. This was clearly due to some special disturbance and action in the Gulf of Martaban, and not to the cyclone in the Bay of Bengal. The *Shahzada*, to the east of Nicobars and Andamans, experienced a shift of wind, which can only be explained by eddying motion of the air of considerable extent. The logs of the only vessels, navigating the Gulf of Martaban at this time and sent in to the Bengal Meteorological Office, and the observations at the Andamans and Nicobars, do not supply sufficient material to discuss the point fully.

APPENDIX A.

Meteorological information extracted from the Log-book of the S. S. "Rajputana" bound from Calcutta to Rangoon.

MONTH OF MAY 1884.		Ship's position at noon.	BAROMETER.		WINDS.		REMARKS.
			Height.	Attached thermometer.	Direction.	Force.	
Thursday, 15th.	4 P.M.	4 miles north of Saugor Light-house.	29'76	87	SW	...	Fresh south-west breeze and fine.
	4-30 P.M.	Saugor Light-house ahead	...	...	...	...	
	8 P.M.	4 miles north-east of East Channel Light Vessel.	29'76	86	S	...	Moderate south wind and fine.
	8-15 P.M.	.....	...	...	...	...	Set course S. 42° E.
	Midnight.	.....	29'76	86	SSE	...	Moderate south-south-easterly wind, and fine clear weather.
Friday, 16th.	4 A.M.	.....	29'72	86	south-easterly.	...	Wind south-easterly unsteady. Fine but cloudy weather.
	8 A.M.	.....	29'74	87	ESE	...	Strong east-south-east wind and head sea.
	Noon.	.....	29'74	85	ESE	...	Strong east-south-easterly wind and heavy head sea.
	2 P.M.	.....	29'65	85	E	...	Wind east increasing to gale.
	4 P.M.	.....	29'57	85	E	...	Wind east moderate gale.
	5-30 P.M.	{ Latitude D. R. 18° 55' N. Longitude 90° 12' E. }	...	...	...	...	Wind increased to gale and heavy sea from eastward. Kept away south, and reduced engines to half speed.
	8 P.M.	.....	29'57	84	E by N	...	Strong gale wind east by north and east-south-east sea. Altered course to east. Still going easy speed.
	9 P.M.	.....	...	...	ENE	...	Heavy gale, and very heavy squalls.
	10 P.M.	.....	29'52	84	NE by N	...	
	11 P.M.	.....	29'50	84	NE	...	Gale increasing with heavy squalls and light drizzling rain. Heavy cloudy appearance all round. Altered course to south-west by west, and ran full speed before it.
	Midnight.	.....	29'49	84	NNE	...	Same weather with more sea.
Saturday, 17th.	1 A.M.	.....	29'44	84	...	...	
	1-30 A.M.	.....	...	...	Northward	...	Wind hauling to the northward. Altered course to south-south-west.
	2 A.M.	.....	29'40	84	N	...	Wind north, very heavy gale and high sea, running to westward.

IN THE BAY OF BENGAL AND AT AKYAB.

Meteorological information extracted from the Log-book of the Ship S. S. "Rajputana" bound
Calcutta to Rangoon.—continued.

MONTH OF MAY, 1884.		Ship's position at noon.	BAROMETER.		WINDS.		REMARKS.
			Height.	Attached thermometer.	Direction.	Force.	
Saturday, 17th contd.	3 A.M.	.....	29°38	84	N by W	...	Same weather, altered course to south.
	4 A.M.	.....	29°36	84	NNW	...	Very heavy gale with terrific squalls accompanied with heavy rain.
	5 A.M.	.....	29°38	84	NW by N	...	Altered course to south by east. Same weather.
	6 A.M.	.....	29°44	84	NW	...	Furious squalls and confused high sea. Altered course south-south-east.
	7 A.M.	.....	29°47	84	NW by W	...	Same weather. Altered course to east-south-east.
	8 A.M.	.....	29°53	84	WNW	...	Squalls continuing and more rain. Altered course to south-east.
	9 A.M.	.....	29°55	84	W by N	...	Weather improving. Altered course to south east by east.
	10 A.M.	.....	29°59	85	WNW	...	Wind decreasing and heavy swell from northward.
	11 A.M.	.....	29°59	86	NW by W	...	Same weather. Altered course to south-east by east $\frac{1}{2}$ east.
	Noon.	.....	29°59	86	NW by W	...	Decreasing with drizzling rain and heavy cross sea.
	1 P.M.	.....	29°62	86	WNW	...	
	1:30 P.M.	.....	...	...	...	...	Altered course to east-south east.
	2 P.M.	.....	29°65	86	W	...	A terrific squall passed over.
	3 P.M.	.....	29°65	86	W by S	...	
	4 P.M.	.....	29°68	86	WSW	...	Still blowing a heavy gale with a high pyramidal sea.
	6 P.M.	.....	29°70	86	SW	...	Gale moderating with every appearance of its clearing up.
	8 P.M.	.....	29°72	86	SSW	...	Fresh gale and cross sea.
	10 P.M.	.....	29°75	86	SSW by S	...	Strong breeze and cross sea.
	Midnight.	.....	29°78	86	S	...	Fresh breeze from south and broken sea.
18th	2 A.M.	.....	29°82	86	...	...	Weather and sea.
	4 A.M.	.....	29°81	85	...	...	Weather and sea.
	6 A.M.	.....	29°83	85	...	...	Weather and sea.
	8 A.M.	.....	29°86	85	...	...	Weather and sea.

SOUTH-WEST MONSOON STORM OF 12TH—17TH MAY

APPENDIX B.

Meteorological information extracted from the Log-book of the Ship "Pemba" bound from Rangoon to Calingapatam—Commander D. Stuart.

MONTH OF MAY 1884.		Ship's position at noon.	BAROMETER.		WINDS.		REMARKS.
			Height.	Attached thermometer.	Direction.	Force.	
15th	4 A.M.	Rangoon towards Calingapatam.	29'650	84	SSW	4	A.M. moderate breeze and cloudy with the threatening rain.
	8 A.M.	.....	'690	84	S	4	.....
	Noon	{ Latitude D. R. 15° 38' N. Longitude 94° 4' E. }	'650	83	SE by E	6	Noon. Strong breeze and hazy weather.
	4 P.M.	.....	'550	84	ESE	6	4 P.M. Strong breeze with falling sea and overcast rainy weather.
	8 P.M.	.....	'570	83	E by S	6	8 P.M. Strong breeze, light rain and lightning in south-east.
	Midnight.	.....	'520	84	ESE	10	Midnight strong gale with heavy showers and rising sea.
16th	4 A.M.	.....	29'400	84	E by S	10	A.M. Strong gale and showery with dense haze to windward.
	8 A.M.	.....	'450	83	East	9	.....
	Noon	{ Latitude D. R. 17° 10' N. Longitude 91° 17' E. }	'400	83	ENE	10	Noon. Strong gale with furious squalls hauled ship's head close to the wind on starboard tack. 2 P.M. Barometor falling rapidly.
	4 P.M.	.....	'280	83	NE	11	.....
	8 P.M.	.....	'200	83	NE	12	8 P.M. till midnight blowing a hurricane with high confused sea and blinding rain.
	Midnight.	.....	'000	83	NE	12	.....
17th	2 A.M.	.....	28'970	83	N	12	A.M. Hurricane.
	4 A.M.	.....	'990	83	NNW	12	8 A.M. Weather beginning to moderate.
	8 A.M.	.....	29'290	83	NW	11	.....
	Noon	{ Latitude D. R. 17° 12' N. Longitude 90° 34' E. }	'460	83	WNW	6	Noon. Fresh breeze with high confused sea.
	4 P.M.	.....	'500	83	West	5	.....
	8 P.M.	.....	'530	83	WSW	4	Midnight. Moderate breeze with overcast sky and heavy sea.
18th	Midnight.	.....	'550	84	W by S	4	.....
	4 A.M.	.....	29'530	83	WSW	4	A.M. Moderate breeze and overcast with heavy south-west swell.
	8 A.M.	.....	'600	83	SW	4	.....
	Noon	{ Obsd. D. R. Latitude 17° 33', 17° 40' N. Longitude 87° 2', 87° 13' E. }	'610	84	SW	4	Noon. Moderate breeze with heavy south-west swell.
	.....	.....	'520	83	SW	4	.....
	.....	.....	'580	83	SW	4	Midnight. hazy with

Meteorological information extracted from the Log-book of the Ship "Pemba" bound from Rangoon to Calingapatam—Commander D. Stuart—continued.

MONTH OF MAY 1885.		Ship's position at noon.	BAROMETER.		WINDS.		REMARKS.
			Height.	Attached thermometer.	Direction.	Force.	
19th	4 A.M.	.....	29°550	83	SSW	4	A.M. Moderate breeze and hazy with heavy south-west swell.
	8 A.M.	.....	'620	83	...	4	.....
	Noon	Latitude D. R. 18° 9' N. Longitude 83° 53' E.	'600	84	...	4	2.15 P.M. Anchored off Calingapatam. No communication with the shore owing to high surf.
	4 P.M.		'510	83	SW	4	.....
	8 P.M.	.....	'570	83	...	4	.....
	Midnight.	.....	'630	83	...	4	.....

SOUTH-WEST MONSOON STORM OF 12TH—17TH MAY

APPENDIX C.

Extracts from a Report by Lieutenant-Colonel H. R. Spearman, Deputy Commissioner, Akyab, on the cyclone of the 17th-18th May 1884 at Akyab.

On the morning of the 17th May the wind at Akyab was from the north-east; gradually it became squally with rain and the sea rose. At 8 A.M., the barometer stood at 29.64, and so remained till a little after 10 h. 30 m., when it began to fall; and at 12 was at 29.48, the wind was veering round to east, and the squalls became stronger. At 2 P.M. the barometer marked 29.46. By 4 P.M. the wind had increased to a gale, and the barometer had gone down to 29.48; the *Brilliant* had gone down one of two lighters which had been alongside the *Fiji* (which was at anchor with the *Rossini* and the *Loch Linnhe* between the mouths of the Satyogya and Jelliapara creeks) had been cast adrift, and had taken the ground, and became a wreck, and the other had been beached, and a lighter had broken adrift from the *Loch Linnhe*. The weather was now very threatening; there were furious squalls, and there was a very heavy sea on. All the three ships paid out as much cable as was safe; the *Loch Linnhe* was hampered by the fear of fouling the *Rossini* as the cyclone veered. At 7 P.M. the wind had veered to east, the barometer was at 29.27, the squalls were terrific with heavy continuous blinding rain, whilst the sea continued rising. At about this time another lighter broke adrift from the *Loch Linnhe* and went ashore. At 8.30 the barometer was at 29.17, and by 8.45 had fallen to 29.10, where it remained till about 9.20. It was now that the cyclone was at its worst, blowing with enormous force, at first from east-south-east, and veering round southward. At 9 there was a lull of about five minutes, when the wind suddenly shifted to south-south-west, and by 9 h. 30 m. the barometer had risen to 29.12. It was at this time that the *Fiji*, the *Rossini*, and the *Loch Linnhe*, took the ground, as did the *Alexander* south of the burial-ground.

From 9 h. 30 m. the barometer continued gradually rising, and the wind decreased and veered round to south-west, but it blew hard all night with heavy and violent gusts. At 6 next morning the barometer marked 29.70, and the wind was from north-west, and at 8 from north-north-west.

Under ordinary circumstances there would have been a rise of the tide on the evening of the 17th May of from 7 to 8 feet: the actual rise was 12 feet, but it is more than doubtful if there was any tidal wave anywhere along the coast.

At daylight on the morning of Sunday, the 18th, it was possible to see what damage had been done. Almost every road to the south of the town was blocked and each in several places by fallen trees and branches. With hardly any exception every private dwelling-house was damaged, and some were almost completely wrecked. Many persons had to leave their houses during the cyclone, and take shelter in those near by which seemed to stand better. The greatest damage was done to the houses on the ridge which extends east and west along the sea-coast and to those along the bank of the Kaladan.

The damage done in the town, as far as it has been able to ascertain it, I give below. One man was killed by a falling tree. There were no other deaths in Akyab:—

I.—NATIVE AND BUSINESS PORTION.

A.—MASONRY BUILDINGS.

a Ruined	21
b More or less damaged	276

B.—WOODEN HOUSES.

a Ruined	112
b More or less damaged	112

C.—MAT AND THATCH HOUSES AND HUTS.

a Ruined	161
b More or less damaged	7,346

Extracts from a Report by Lieutenant-Colonel H. R. Spearman, Deputy Commissioner, Akyab, on the cyclone of the 17th-18th May 1884 at Akyab.

The estimated value is given as about, or a little over, a lakh of rupees.

D.—GRAIN.

a Paddy	40,000 baskets.
b Rice	1,700 do.

The estimated value is about ₹11,000.

E.—FRUIT TREES.

Blown down	3,480
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The estimated value is about ₹3,000.

F.—SHIPS AND BOATS IN AKYAB (PRIVATE PROPERTY).

(a) Lost.

1 Russian ship wrecked.	10 Cargo-boats (Arakanese).
2 Native brig.	19 Passenger boats (Indian).
1 Civil Surgeon's boat (English-built).	34 Fishing boats.
7 Cargo boats (Indian).	12 Canoes.

(b) Damaged.

4 Cargo-boats.	3 Ships driven ashore.
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G.—GOODS.

Goods of all kinds except grain stored in houses, &c.; value ₹37,000. In addition to this the damage done to schools, monasteries and ecclesiastical buildings is estimated at ₹4,500.

H.—CATTLE.

Seventy-five head are said to have died in Akyab from exposure, valued at about ₹1,600.

II.—EUROPEAN PORTION.

It is impossible to make any estimate of this. Very few houses escaped damage of some kind or other.

AKYAB DISTRICT.

The first reports received were very discouraging, and turned out to be much exaggerated. The reporting officers seem to have been much frightened, and to have lost power of criticizing the loose statements they received, which they forwarded as they got them. The tracts which suffered most are those along the coast from Akyab westwards, that is to say, Kyelet and parts of Rathedaung and Naaf. The storm was felt almost everywhere more or less, extending northwards into the Arakan Hill Tracts, where it seems to have arrived at about 7 or 8 on the evening of the 17th, and to have attained its greatest violence between 1 and 2 on the morning of the 18th. That part of the Akyab district which felt the cyclone least is that lying to the eastward of a line drawn about due north from Akyab, that is, the Urittaung East, Minbya, and Myohang townships, paths of Kaladan and Urittaung West, and the north-west portion of Rathedaung were seriously injured by falling trees, and the road was almost impassable for foot traffic by numerous landslips and by trees blown down across the roadway. Many villages suffered largely, but the stocks of grain were comparatively small, almost the whole surplus having been disposed of. There was no doubt a considerable loss due to the storm removing the protecting roofs and walls of houses and store-sheds, and probably about 30,000 baskets of paddy and 10,000 baskets of rice have been destroyed or very seriously damaged. Cattle also suffered from exposure and cold. There were six deaths from drowning (two of children) and five from falling trees or houses.

The damage done generally was no doubt great, but I am not by any means disposed to consider it so great that special measures of relief should be adopted, whether by way of grants or by remissions. I think it possible that remissions might be recommended in special cases, but I would leave matters alone at present and consider special cases as they arise.

I append statements showing barometrical readings, the estimated loss of life, and the estimated loss of property. The estimates approximate only and in varying degrees of accuracy.

38 SOUTH-WEST MONSOON STORM OF 12TH-17TH MAY, BAY OF BENGAL AND AKYAB.

HOUR.		Barometric readings uncorrected.	Barometer corrected and reduced to sea-level.	REMARKS.	
17th May .	8 } 10 } 12 }	A.M. .	29.64 29.64 29.48	29.52 '52 '36	Wind north-east, very cloudy. Fresh north-east wind and squally.
	2 } 4 } 6 }		29.46 29.40 29.29	'34 '28 '17	Heavy and frequent squalls from north-east and east north-east.
	7 } 8 }		29.27 29.19	'15 '05	Wind due east with terrific squalls.
	8-30 } 8-45 }		29.17 29.10	28.98 '98	Wind east-south-east with frequent heavy squalls; cyclones blowing with great force.
	9 } 9-30 } 9-45 }	P.M.	29.10* 29.12 29.17	29.00 '05 '09	* Here there was a lull about five minutes, and the wind suddenly shifted to south-south-west.
	10 }		29.21	'12	
	10-30 }		29.24	'23	Wind decreasing south-south-west to south-west.
	11 }		29.35	'38	
	11-30 }		29.50	'39	
	11-45 }		29.51	'58	South-west.
	6 }		29.70	'63	North-west.
	8 }	A.M. .	29.75	...	North-north-west.

Statement of damage done by the Cyclone of May 1884, Akyab District.

No.	LOCALITY.	Deaths of human beings.	Deaths of cattle.	HOUSES AND GODOWNS		Grain destroyed and damaged in Arakan baskets of 24 lbs.	REMARKS.
				Wrecked.	Damaged.		
1	Urittaung East .	...	71	370	1,400	10,000	i.—Amongst houses are included paddy stores and sheds.
2	Minbya .	...	...	100	700	1,000	
3	Myohaung .	...	...	20	100	1,000	ii.—The loss of grain in Kyelet is, I think, too high. My own estimate from general enquiries is from 50,000 to 60,000 baskets at most.
4	Kaladan .	3	...	250	400	1,000	iii.—The figures for the Naaf are, in my opinion, too high, especially as regards cattle and houses wrecked.
5	Urittaung West .	...	150	300	500	15,000	I estimate the loss of cattle at about 100 and of houses at from 500 to 600.
6	Kyelet .	2	250	525	4,000	119,000	
7	Rathedaung .	31	50	500	1,300	10,000	
8	Naaf .	11	400	1,800	3,500	40,000	
9	Akyab Town .	2	75	182	4,374	42,000	
TOTAL .		49	996	4,047	16,274	239,000	

14TH MAY 1884.



15TH MAY 1884.



16TH MAY 1884.



17TH MAY 1884.



BAROMETRIC AND WIND CHARTS
AT 10 A.M.

II.—On the Diurnal Variation of the Rainfall at Calcutta.—By HENRY F. BLANFORD,
F.R.S. (With Plate III.)

IN the 48th Volume of the Journal of the Asiatic Society (Part II for 1879), I gave the results of twenty-one years' hourly registration of the occurrence of rain, at the house formerly occupied by the Surveyor General's Office in Park Street, Chowringhee. The data discussed related only to the fact of rain falling between certain hours, and took no note of the quantity of the fall. The result, therefore, had reference only to the relative frequency of rain at different hours of the day. The additional data, which form the subject-matter of the present note, are the records of only seven years or of one-third of the former period. But, inasmuch as they have been furnished by the traces of a self-registering (Beckley's) rain-gauge, they show not only the hourly frequency but also the hourly quantities of rain; and while, on the former point, they merely serve to confirm, with some slight modification, the conclusions formerly arrived at; on the latter, they afford new matter of some interest.

The Hyetograph, which has furnished the data here considered, is one constructed by Messrs. Casella. It consists of a bucket, with counterpoise, which empties itself automatically, when filled with rainwater, corresponding to a fall of 0·2 inch on the area of the receiving funnel; and each filling of the bucket, as well as each partial filling, is recorded by a pencil on the ruled form, which is attached to a cylinder made to revolve by a driving clock. This portion of the apparatus is fixed in a small turret room in the upper portion of one of the four turrets surmounting the building of the Alipore Observatory. The collecting funnel is placed centrally above it, on the apex of the roof, 50 feet above the ground; and the rim of the funnel is armed with points of sharpened wire, to render it an uneasy perch for the curiously inquisitive avifauna of the Calcutta suburbs. From the collecting funnel, the rainwater is conducted by a vertical brass pipe, to the tip bucket of the registering apparatus, immediately above which it terminates in a contracted nozzle.

The tip bucket of the gauge was found, by a prolonged verification, to have a mean error of—0·08 inch per inch of rainfall, and a correction, proportional thereto, has been applied to all the measurements here given. On the average of the seven years' registers, the rainfall registered by the turret gauge, 50 feet above the ground, (after correction) is found to be in the ratio of one inch, for 1·12 inches received by the Symon's gauge in the Observatory compound below, the mouth of which is one foot above the level of the ground. This is in the ratio of 0·893: 1 or approximately $\frac{9}{10}$.

HOURLY FREQUENCY OF RAINFALL.

The registers extend from January 1878 to December 1884, a period of exactly seven years. I will deal, in the first place, with the frequency of the rainfall, tabulating the data in the same manner as in my former paper.

TABLE I.—Showing the number of hours in which rain was recorded at the Alipore Observatory, during 7 years, from 1st January 1878 to 31st December 1884.

HOURS, A.M.

MONTHS.	Midnight to 1.	1 to 2.	2 to 3.	3 to 4.	4 to 5.	5 to 6.	6 to 7.	7 to 8.	8 to 9.	9 to 10.	10 to 11.	11 to Noon.	Midnight to Noon.
January	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.
February	Nil.	Nil.	3	3	3	3	Nil.	3	1	2	Nil.	Nil.	18
March	3	4	3	3	3	Nil.	1	1	Nil.	Nil.	1	1	20
April	4	3	7	3	4	2	2	2	1	1	Nil.	Nil.	29
May	6	4	1	3	1	3	3	3	5	6	3	6	44
June	18	15	19	15	21	23	16	17	13	16	21	20	214
July	38	28	38	43	42	35	34	31	24	31	25	37	406
August	24	24	28	36	34	32	36	35	25	26	27	35	362
September	17	15	16	17	16	19	20	17	20	20	26	32	235
October	3	7	5	7	6	5	13	8	9	11	10	9	93
November	Nil.	1	1	Nil.	Nil.	2	2	2	1	1	1	1	12
December	4	4	3	2	3	1	2	2	2	2	3	2	30
YEARLY TOTAL .	117	105	124	132	133	125	129	121	101	116	117	143	1,463

HOURS, P.M.

MONTHS.	Noon to 1.	1 to 2.	2 to 3.	3 to 4.	4 to 5.	5 to 6.	6 to 7.	7 to 8.	8 to 9.	9 to 10.	10 to 11.	11 to Midnight.	Noon to Midnight.
January	Nil.	Nil.	1	Nil.	1	Nil.	Nil.	1	1	Nil.	1	Nil.	5
February	Nil.	1	3	3	4	3	4	4	4	4	3	2	35
March	2	1	2	1	4	5	6	5	6	5	3	4	44
April	Nil.	1	1	Nil.	2	3	8	17	15	12	7	3	69
May	8	12	7	11	12	16	24	23	26	18	15	13	185
June	26	30	32	21	35	28	22	27	27	18	18	19	303
July	45	41	53	51	57	48	44	43	35	27	27	28	499
August	48	50	45	43	42	35	34	30	24	24	20	23	418
September	31	36	37	40	32	17	19	18	13	13	9	16	281
October	10	15	17	16	12	13	7	11	8	4	4	1	118
November	Nil.	Nil.	1	2	1	3	1	1	Nil.	1	1	1	12
December	2	3	4	4	2	3	4	5	4	4	3	4	42
YEARLY TOTAL .	172	190	203	92	204	174	173	185	163	130	111	114	2,011

As these figures give the total number of rainy hours in 7 years, if multiplied by 3, they may be compared directly with those of the former table, based on 21 years' registers. In the following table, this comparison is made for the annual totals of each of the 24 hours, and also for the hourly sums of each of the three seasons, *viz.*, the cold season (November to February), the rains (June to October), and the hot season (March to May).

TABLE II.—Comparison of the hourly frequency of rain at Calcutta in 21 years (1856-77) and 7 years (1878-84).

Hours.	YEAR.		NOVEMBER TO FEBRUARY.		MARCH TO MAY.		JUNE TO OCTOBER.	
	21 years	7 years X3	21 years	7 years X3	21 years	7 years X3	21 years	7 years X3
Mid to 1 . . .	343	351	17	12	28	39	298	300
1 to 2 . . .	374	315	18	15	29	33	327	267
2 to 3 . . .	409	372	29	21	32	33	348	318
3 to 4 . . .	410	396	29	15	28	27	353	354
4 to 5 . . .	414	399	29	18	21	24	364	357
5 to 6 . . .	426	375	26	18	24	15	376	342
6 to 7 . . .	430	387	29	12	28	18	373	357
7 to 8 . . .	426	363	28	21	25	18	373	324
8 to 9 . . .	409	303	28	12	24	18	357	273
9 to 10 . . .	461	348	21	15	30	21	410	312
10 to 11 . . .	522	351	35	12	29	12	458	327
11 to 12 . . .	565	429	27	9	33	21	505	399
12 to 13 . . .	603	516	24	6	30	30	543	480
13 to 14 . . .	600	570	25	12	38	42	537	516
14 to 15 . . .	646	609	27	27	47	30	572	552
15 to 16 . . .	571	576	28	27	66	36	477	513
16 to 17 . . .	566	612	33	24	69	54	464	534
17 to 18 . . .	544	522	29	27	102	72	413	423
18 to 19 . . .	521	519	25	27	99	114	397	378
19 to 20 . . .	495	555	27	33	125	135	343	387
20 to 21 . . .	449	489	19	27	109	141	321	321
21 to 22 . . .	361	390	19	27	81	105	261	258
22 to 23 . . .	360	333	17	24	61	75	282	234
23 to mid . . .	319	342	22	21	34	60	263	261

In most of their main features, the two registers shew as much agreement as could be expected, seeing that the irregularities from hour to hour, that are to a certain extent eliminated from the 21 years' register, are retained in their full relative proportion (tripled absolutely) in the 7 years' register. There is, however, one differential feature, which hardly has the appearance of a casual irregularity, *viz.*, the relative deficiency of

the 7-year series between the hours of 6 A. M. and 1 P. M., and greatest between 10 and 11 A. M. This deficiency appears in all three seasons separately, as well as in the annual table. Whether it be due to the change in the site of the Observatory, or to some difference in the average atmospheric conditions of the last seven years, can at present be only a matter of surmise. The following table which gives the difference of the 7 years' series, compared with the 21 years' series as a standard, exhibits this feature very clearly.

TABLE III.—*Difference of the 21 year and 7 year, (tripled) hourly results.*

	Mid to 1.	1 to 2.	2 to 3.	3 to 4.	4 to 5.	5 to 6.	6 to 7.	7 to 8.	8 to 9.	9 to 10.	10 to 11.	11 to Noon.
November to February . . .	-5	-3	-8	-14	-11	-8	-17	-7	-16	-6	-23	-18
March to May . . .	+11	+4	+1	-1	+3	-9	-10	-7	-6	-9	-17	-12
June to October . . .	+2	-60	-30	+1	-7	-34	-16	-49	-84	-98	-131	-106
Year . . .	+8	-39	-37	-14	-15	-51	-43	-63	-106	-113	-171	-136

	Noon to 1.	1 to 2.	2 to 3.	3 to 4.	4 to 5.	5 to 6.	6 to 7.	7 to 8.	8 to 9.	9 to 10.	10 to 11.	11 to Mid.
November to February . . .	-18	-13	0	-1	-9	-2	+2	+6	+8	+8	+7	-1
March to May . . .	-6	+4	-17	-30	-15	-30	+15	+10	+32	+24	+14	+26
June to October . . .	-63	-21	-20	+36	+70	+10	-19	+44	0	-3	-48	-2
Year . . .	-87	-30	-37	+5	+46	-22	-2	+60	+40	+29	-27	+23

By substituting for the tabular value of each hourly term, the sum of half that value, and one-fourth of each of the preceding and following terms, most of the minor irregularities are eliminated, and the following results are obtained (Table IV), which are plotted as curves in figures 1 to 4 (Plate III). In this table, the original, not the tripled values, are used. In the figures 1 to 4 (Plate III) both the 7-year and 21-year curves are given; the former a continuous, the latter a dotted line; the scale values of the ordinates of the latter being three times as great as those of the former. Before plotting, the original figures of the 21-year curve have been smoothed by the same process as those in the following table.

TABLE IV.—*Smoothed values of the hourly frequency of rain according to the registers of 7 years.*

	Mid to 1.	1 to 2.	2 to 3.	3 to 4.	4 to 5.	5 to 6.	6 to 7.	7 to 8.	8 to 9.	9 to 10.	10 to 11.	11 to Noon.
November to February . . .	5	5	6	6	6	6	5	5	5	4	4	3
March to May . . .	17	12	10	9	7	6	6	6	6	6	6	7
June to October . . .	94	96	105	115	117	116	115	106	98	102	114	134
Year . . .	116	111	121	130	130	128	126	117	109	112	124	144

	Noon to 12.	12 to 14.	14 to 15.	15 to 16.	16 to 17.	17 to 18.	18 to 19.	19 to 20.	20 to 21.	21 to 22.	22 to 23.	23 to Mid.
November to February	3	5	8	9	9	9	10	10	10	9	8	6
March to May	10	12	12	13	18	26	36	44	43	36	26	20
June to October	156	172	178	176	167	146	130	123	107	89	82	88
Year	169	189	198	198	194	181	176	177	160	134	116	114

The diurnal variation of rain frequency, as represented in these curves, thus presents three different types in the three seasons, the characteristic features of which are as follow:—

In the *cold season*, notwithstanding the comparative rarity of rain, the diurnal variation is very distinct, its frequency at the hour of maximum being three times as great as at that of minimum. The absolute minimum of frequency falls about noon; from which time it rises to a maximum between 6 and 9 P.M., and then falls to a secondary minimum between midnight and 2 A.M. From 2 to 6 A.M. rain is slightly more frequent; and after that hour it declines gradually to the minimum at noon.

This course of variation differs from that formerly deduced from 21 years' observations, in that, in the latter, the former places of the absolute and the secondary minimum are mutually transposed, and that the absolute maximum in the 21-year curve, between 4 and 5 P.M., was less than twice as great instead of being three times as great as the absolute minimum before midnight.

In the *hot season*, there is but one well-defined maximum and one less determinate minimum, the former very decidedly between 6 and about 8 P.M., the latter somewhat indefinitely between sunrise and 11 A.M. After this latter hour, rain is slightly more frequent up to 4 P.M., and then it increases rapidly to the maximum at 8 P.M., when it is 7 or 8 times as frequent as in the forenoon. The curve then falls with equal rapidity to about 11 P.M., and further slowly to sunrise.

The 21 years' curve of this season has very much the same general character, except that the difference of the forenoon minimum and evening maximum is less pronounced, the former being more than one-fourth of the latter. The epoch of the minimum is more defined and is about 5 A.M. or sunrise.

In the *rainy season*, the hour of least frequency is between 10 and 11 P.M. From this hour, rain increases in frequency up to about 5 A.M. It then again decreases till about 9 A.M., increases again to an absolute maximum about 3 P.M. and then falls rapidly to the absolute minimum, with a slight relaxation of the fall between 6 and 8 P.M. At the maximum, the frequency is rather more than twice as great as at the minimum.

In the 21 years' curve, the minimum occurs at the same hour, but the rise thence is regular and rapid up to 6 A.M. A slight fall follows, for an hour and a half, and the rise then continues rapidly to the maximum between 1 and 2, about an hour earlier than in the 7-year curve. From this, the fall to the minimum is rapid and steady.

It was pointed out, in my former paper, how certain critical epochs of these curves coincide with those of the curves of diurnal temperature and pressure. In the rainy

season, which is that of a nearly saturated atmosphere, the absolute minimum coincides almost exactly with the nocturnal maximum of pressure. The first maximum very nearly with the minimum of temperature. The secondary minimum precedes by about an hour and a half, the forenoon maximum of pressure: and the absolute maximum almost exactly coincides with that of temperature. The slight retardation in the fall between 6 and 8 P.M. is evidently due to the same causes as those which produce the absolute maximum of the preceding hot season.

In the hot and dry season, the hours between sunrise and 11 A.M. are those of least frequent rain in the 7-year curve: in the 21-year curve, the minimum hour is more definitely indicated at sunrise; and, in both, the increase is rapid in the afternoon hours, the epoch of maximum, determined by the evening thunder storms, being coincident with the most rapid fall of temperature. These storms appear to be to a certain extent catastrophic in character, and to originate in a disturbance of the vertical equilibrium of the atmosphere.

In the cold weather curve for the 7 years, this tendency to evening storms seems to determine the epoch of maximum, although but slight in comparison with the hot season.

HOURLY QUANTITY OF RAINFALL.

I now pass to the consideration of the hourly variation in the quantity of the fall, for which my only data are those of the past 7 years. The totals of the 7 years, recorded at each hour of each month, are given in the following table V.

TABLE V.—*Shewing the total hourly rainfall recorded at the Alipore Observatory, during seven years, from 1st January 1878 to 31st December 1884.*

HOURS, A.M.

Month.	Midnight to 1.	1 to 2.	2 to 3.	3 to 4.	4 to 5.	5 to 6.	6 to 7.	7 to 8.	8 to 9.	9 to 10.	10 to 11.	11 to Noon.	Midnight to Noon.
January	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.	Nil.
February	Nil.	Nil.	0'50	0'19	0'09	0'30	Nil.	0'33	0'50	0'27	Nil.	Nil.	2'18
March	0'08	0'20	0'38	0'20	0'16	Nil.	0'03	0'01	Nil.	Nil.	0'01	0'30	1'37
April	0'12	0'12	0'28	0'13	0'24	0'13	0'04	0'02	0'01	0'01	Nil.	Nil.	1'10
May	0'40	0'04	0'19	0'26	0'06	0'07	0'04	0'56	0'44	0'90	0'12	0'54	3'62
June	3'19	2'81	2'06	0'79	1'65	1'53	1'34	0'86	2'04	1'22	4'03	1'24	22'76
July	1'92	2'29	3'13	4'21	3'33	3'23	2'80	1'90	1'68	2'29	2'47	3'09	32'34
August	1'50	1'92	3'78	3'79	4'57	3'94	2'32	4'48	3'30	2'13	2'36	5'53	39'62
September	1'42	1'02	1'87	3'33	1'51	2'11	2'27	12'97	2'77	2'16	3'83	7'70	32'96
October	0'49	0'24	0'46	0'23	0'15	0'55	4'12	2'21	0'68	0'66	1'11	1'31	12'21
November	Nil.	0'01	0'01	Nil.	Nil.	0'19	0'05	0'05	0'18	0'13	0'02	0'13	0'77
December	0'39	0'12	0'31	0'14	0'24	0'33	0'07	0'06	0'04	0'05	0'09	0'02	1'86
YEARLY TOTAL .	9'51	8'77	12'97	13'27	12'00	12'38	13'08	13'45	11'64	9'82	14'04	19'86	150'79

RAINFALL AT CALCUTTA.

45

HOURS, P.M.

MONTH.	Non to 12.	12 to 1.	1 to 2.	2 to 3.	3 to 4.	4 to 5.	5 to 6.	6 to 7.	7 to 8.	8 to 9.	9 to 10.	10 to 11.	11 to 12.	12 to Midnight.	Non to Midnight.
January . . .	Nil.	Nil.	0'11	Nil.	0'03	Nil.	Nil.	0'01	0'05	Nil.	0'02	Nil.	0'22	•	•
February . . .	Nil.	0'03	0'53	0'42	0'42	2'32	0'24	0'68	0'09	0'96	0'64	0'07	6'93	•	•
March . . .	0'08	0'02	0'02	0'01	0'07	1'10	0'72	1'02	0'36	0'28	0'26	0'14	4'08	•	•
April . . .	Nil.	0'06	0'08	Nil.	0'21	0'38	1'55	2'52	2'11	1'07	1'00	0'10	9'08	•	•
May . . .	1'11	2'04	1'02	1'57	2'26	2'20	5'30	3'92	4'23	1'49	1'37	1'59	28'10	•	•
June . . .	2'83	4'41	3'49	2'39	4'45	5'20	2'45	5'83	4'25	1'09	0'81	0'98	38'18	•	•
July . . .	3'82	4'47	3'67	6'66	4'33	4'86	5'52	5'74	2'80	1'88	1'12	1'71	46'58	•	•
August . . .	5'81	4'25	4'63	4'15	3'61	2'88	2'74	3'08	1'90	1'27	1'01	2'55	37'88	•	•
September . . .	4'89	4'55	4'41	4'05	4'35	3'00	2'46	1'91	0'90	0'93	1'33	1'23	34'01	•	•
October . . .	1'15	1'45	2'90	1'72	0'88	0'92	0'30	0'96	0'28	0'07	0'49	0'01	11'13	•	•
November . . .	Nil.	Nil.	0'02	0'67	0'78	0'17	0'05	0'01	Nil.	0'01	0'02	0'03	1'76	•	•
December . . .	0'05	0'08	0'23	0'11	0'05	0'18	0'10	0'15	0'17	0'20	0'24	0'26	1'82	•	•
YEARLY TOTAL . . .	19'74	21'36	21'11	21'75	21'44	23'21	21'43	25'83	17'67	9'25	8'31	8'67	219'77	•	•

And in the following Table VI, the monthly sums are grouped for the three seasons as in the previous table (II) of frequency, except that they are not multiplied by 3; and in parallel columns are given the smoothed values: ¹

TABLE VI.—Total hourly rainfall (observed and smoothed values) at the Alipore Observatory during seven years.

HOURS.	YEAR.		NOVEMBER TO FEBRUARY.		MARCH TO MAY.		JUNE TO OCTOBER.	
	Observed.	Computed.	Observed.	Computed.	Observed.	Computed.	Observed.	Computed.
Mid to 1 . . .	9'51	9'26	0'39	0'38	0'60	0'99	8'52	7'89
1 to 2 . . .	8'77	10'29	0'13	0'40	0'36	0'65	8'28	9'24
2 to 3 . . .	12'97	11'72	0'82	0'47	0'85	0'62	11'30	10'63
3 to 4 . . .	13'27	12'54	0'33	0'47	0'59	0'58	12'35	11'49
4 to 5 . . .	12'00	12'54	0'33	0'47	0'46	0'43	11'21	11'64
5 to 6 . . .	12'38	12'57	0'82	0'47	0'20	0'28	11'36	11'82
6 to 7 . . .	13'08	12'84	0'12	0'43	0'11	0'29	12'85	12'12
7 to 8 . . .	13'45	12'61	0'44	0'45	0'59	0'43	12'42	11'73
8 to 9 . . .	11'64	11'88	0'72	0'51	0'45	0'56	10'47	10'81
9 to 10 . . .	9'82	12'18	0'45	0'41	0'91	0'58	8'46	11'19
10 to 11 . . .	14'04	14'65	0'11	0'24	0'13	0'59	13'80	13'82
11 to Noon . . .	19'86	17'84	0'15	0'13	0'84	0'83	18'87	16'88

¹ In computing these, the formula $c' = \frac{a+4b+6c+4d+e}{16}$ has been used, when a, b, c, d, e represent the original values of five consecutive terms, and c' the smoothed value of the third term of the series.

TABLE VI.—Total hourly rainfall (observed and computed values) at the Alipore Observatory during seven years—continued.

Hours.	YEAR.		NOVEMBER TO FEBRUARY.		MARCH TO MAY.		JUNE TO OCTOBER.	
	Observed.	Computed.	Observed.	Computed.	Observed.	Computed.	Observed.	Computed.
Noon to 13	19'74	19'91	0'05	0'13	1'19	1'26	18'50	18'50
13 to 14	21'36	20'82	0'11	0'36	2'12	1'52	19'43	18'94
14 to 15	21'11	21'20	0'89	0'74	1'12	1'52	19'10	18'94
15 to 16	21'75	21'58	1'20	1'17	1'58	1'87	18'97	18'54
16 to 17	21'44	21'94	1'28	1'53	2'54	2'88	17'62	17'60
17 to 18	23'21	22'40	2'67	1'55	3'68	4'47	16'86	16'38
18 to 19	21'43	22'74	0'39	1'16	7'57	6'20	13'47	25'38
19 to 20	25'85	21'49	0'85	0'87	7'46	6'77	17'52	13'85
20 to 21	17'67	17'25	0'81	0'90	6'70	5'72	10'43	10'63
21 to 22	9'25	12'05	1'17	0'95	2'84	3'98	5'74	7'12
22 to 23	8'31	9'25	0'92	0'80	2'63	2'57	4'76	5'88
23 to Mid.	8'67	8'77	0'36	0'54	11'83	1'70	16'48	16'53

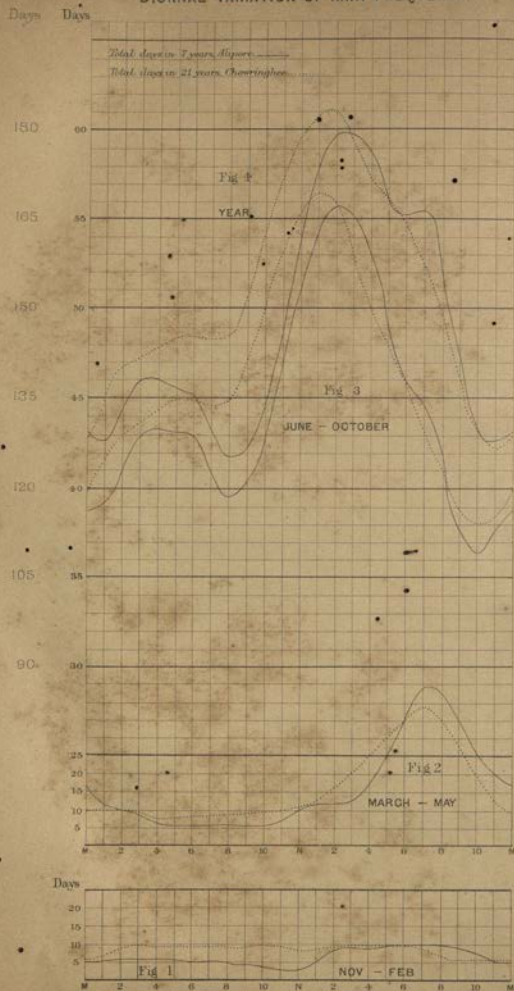
The diurnal variation of the quantities of rainfall at the three seasons, agrees in most characters with that of frequency, but certain features are more pronounced.

In the *cold season*, the minimum is very decided about noon, and the maximum equally so at 5 P.M., the latter being more than ten times as great as the former.

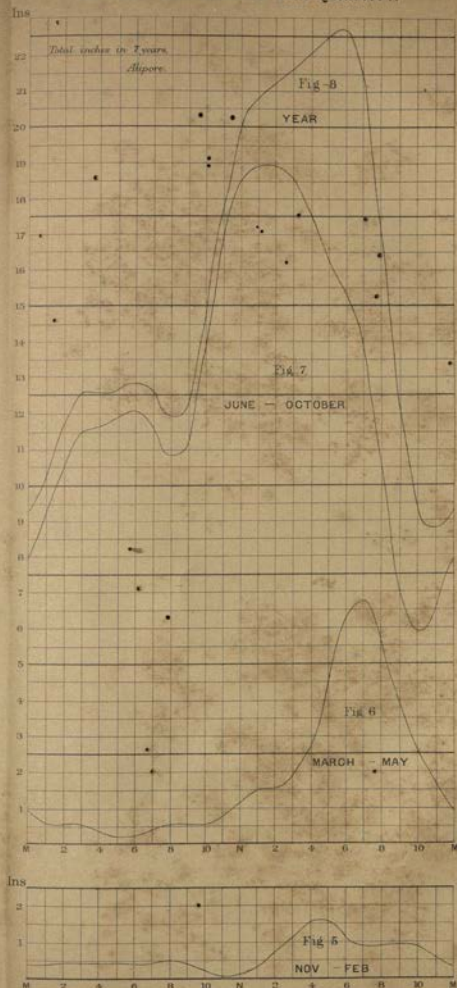
In the *hot season*, the minimum is very marked at 6 A.M., a little after the average time of sunrise; and the maximum about 7 P.M., when the fall is more than twenty times as great as the former hour.

And, finally, in the *rainy season*, the absolute minimum is a little before 11 P.M.; the first maximum about half past 6 A.M., or an hour after the average time of sunrise; the second minimum between 9 and 10 A.M., (coinciding with the absolute maximum of pressure); and the absolute maximum at 2 P.M., when the quantity is more than three times as great as at the hour of absolute minimum.

DIURNAL VARIATION OF RAIN FREQUENCY.

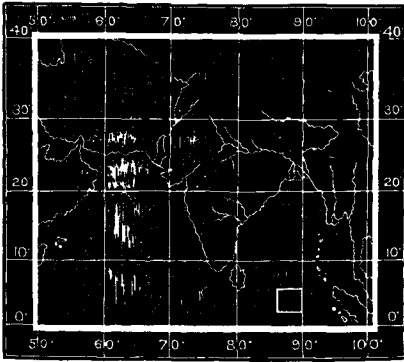


DIURNAL VARIATION OF RAIN QUANTITY.



III.—The Meteorological features of the southern part of the Bay of Bengal, by W. L. DALLAS, Assistant Meteorological Reporter to the Government of India. (With Plate IV.)

THE portion of the Bay of Bengal, the meteorological features of which form the



subject of the present Memoir, is situated between the parallels of 2° and 6° north latitude and 86° and 90° east longitude. This portion of the Bay was selected because, in the first place, in virtue of its position it is that which is most free from the influence of neighbouring land, and probably illustrates fairly well the meteorological changes which are produced by the revolution of the seasons in, what may be termed, the free atmosphere of an oceanic tract; and, in the second, because it is traversed by a large proportion of the ships proceeding into the Bay of Bengal; more

particularly those from the Australian ports.

In tropical seas, the main meteorological changes of any one part are, as a rule, very fairly representative of a considerable area, so that it is hoped that the discussion of the small portion, now selected, may afford a trustworthy basis for estimating the changes that affect that part of the Indian Ocean which stretches from the equator northward to Ceylon and the Nicobars.

Pressure.—In describing the meteorological features of the area in question, I begin with that of atmospheric pressure, which may conveniently be considered under the main headings of its annual and diurnal march. The first line of figures in the following table gives, in the first of the double columns, the mean barometric readings for each month of the year. They are simply the arithmetical means of all the observations recorded within the area, corrected for the diurnal variation. The second columns give the difference of these means from the average of the whole year; and below these, in the second line, is recorded the number of observations from which each mean is deduced. With a view to eliminating any irregularity due to faulty instruments or readings and the minor

a-periodical variations, from these mean values, the co-efficients of the following formula were computed,

$$\begin{aligned}
 &= 29.880 + .0258 \sin (n \cdot 30^\circ + 120^\circ 10') \\
 &\quad + .0112 \sin (n \cdot 60^\circ + 19^\circ 35') \\
 &\quad + .0024 \sin (n \cdot 90^\circ + 65^\circ 16') \\
 &\quad + .0041 \sin (n \cdot 120^\circ + 195^\circ 29')
 \end{aligned}$$

and substituting for n the ordinal values of the months, the results shewn in the last line of the Table. The principal difference exhibited in these computed values, as compared with the simple means, is the obliteration of the slight irregularity in July which is noticed below—

JANUARY.		FEBRUARY.		MARCH.		APRIL.		MAY.		JUNE.	
P.	d.	P.	d.	P.	d.	P.	d.	P.	d.	P.	d.
29.915	+035	29.895	+015	29.892	+012	29.861	—019	29.842	—038	29.857	—023
Obs. 552		530		699		491		187		107	
29.907		29.902		29.889		29.861		29.846		29.852	

JULY.		AUGUST.		SEPTEMBER.		OCTOBER.		NOVEMBER.		DECEMBER.	
P.	d.	P.	d.	P.	d.	P.	d.	P.	d.	P.	d.
29.852	—028	29.878	—002	29.892	+012	29.886	+006	29.892	+012	29.893	+013
Obs. 124		158		340		499		321		362	
29.858		29.874		29.893		29.889		29.886		29.901	

Mean of whole year 29.880.

It will be seen from the above table that, roughly speaking, the annual march of pressure would be represented by a curve decreasing from a maximum in January to a minimum in May, and increasing again by very small amounts to the January maximum. This main march is however interrupted by two distinctly marked irregularities.* In the first place, there is a very slight secondary minimum in July; and in the second place there occurs a very distinct minimum in October. The occurrence of the epoch of annual minimum pressure in May seems to be common to the whole of the more southern portion of the Indian area, while the slight decrease in July is either an accidental irregularity, or a slight depression, in sympathy with the fall which, during this period, occurs over the greater part of Bengal and the Eastern Peninsula. The secondary minimum in the autumn is of a different character. All the meteorological phenomena which have long been recognised round the Bay, during this period, indicate an abnormal low pressure area in the south; and the chart of the average distribution of pressure over the Bay, in

October, shows that, over the eastern and southern portion, there is a large area of relatively low pressure, due very probably to the frequency of cyclonic storms in this region. The recurrence of the abnormally low pressures, which accompany such storms, may perhaps account for the secondary minimum noticed above.

The column of differences in the above table shows that pressure is above the average of the year during seven and below it during five months of the year. The extreme departures from the mean in either direction are about equal; the greatest minus variation being 0.038 inch in May, the greatest plus variation 0.035 inch in January; which give a total annual range of 0.073 inch.

The next subject of importance is the diurnal fluctuation of the barometer, the progress of which, computed from the observations at intervals of 4 hours,¹ is shewn in the following table, and graphically on Plate IV. The numerical values of the co-efficients of the harmonic formula are given in an Appendix (p. 57).

Hrs.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Mid-night.	inch. +014	inch. +013	inch. +006	inch. +001	inch. +001	inch. +014	inch. +014	inch. +017	inch. +007	inch. +015	inch. +016	inch. +006
1	-005	-004	-010	-013	-014	-001	+001	+001	-007	-003	-002	-011
2	-022	-020	-023	-024	-026	-015	-011	-015	-018	-019	-020	-024
3	-032	-029	-030	-028	-032	-023	-018	-025	-023	-030	-030	-030
4	-031	-028	-028	-025	-028	-024	-019	-026	-021	-030	-030	-027
5	-020	-016	-018	-015	-017	-016	-013	-016	-011	-019	-020	-015
6	0	+003	-001	0	+001	-001	-002	+001	+004	+001	-001	+001
7	+022	+024	+018	+018	+020	+016	+012	+021	+021	+022	+019	+020
8	+040	+041	+035	+034	+037	+031	+024	+037	+035	+040	+037	+036
9	+049	+048	+046	+046	+047	+040	+031	+044	+042	+048	+045	+044
10	+046	+044	+047	+048	+047	+039	+031	+040	+041	+044	+042	+043
11	+032	+029	+037	+040	+037	+029	+022	+027	+030	+030	+020	+032
12	+010	+008	+019	+023	+020	+012	+008	+008	+012	+009	+009	+012
13	-014	-014	-004	0	-002	-009	-010	-012	-008	-013	-014	-011
14	-035	-033	-026	-024	-022	-028	-026	-029	-027	-031	-033	-031
15	-048	-044	-041	-041	-036	-041	-037	-040	-040	-042	-044	-044
16	-050	-046	-046	-047	-040	-045	-040	-042	-043	-044	-046	-046
17	-041	-039	-039	-040	-035	-039	-033	-037	-037	-038	-038	-037
18	-024	-024	-023	-025	-021	-025	-020	-026	-023	-025	-023	-019
19	-003	-006	-003	-005	-004	-006	-003	-010	-006	-007	-003	+001
20	+017	+012	+015	+015	+012	+012	+013	+007	+010	+010	+016	+019
21	+031	+025	+026	+023	+021	+025	+024	+021	+021	+024	+029	+030
22	+035	+030	+028	+023	+022	+030	+028	+028	+023	+030	+034	+030
23	+029	+025	+020	+015	+014	+025	+024	+027	+018	+027	+029	+021

¹ The data for this table include all the readings recorded between the equator and N. lat. 10°, and between 80° and 90° E. long.

The general character of the diurnal oscillation agrees fairly with that of most tropical places, but exhibits in its details certain marked differences when compared with the curves of daily oscillation recorded on the plains of India.

At about half past 3 A. M. pressure begins to rise. In the first hour and a half or two hours the increments are slight, but as the sun rises they become more rapid. The maximum is attained soon after 9 A.M. in most months, but at about half past nine during the months March to July. After reaching the diurnal maximum, pressure falls quickly, and reaches its minimum at about 15h. 40 min.; though here, also, there is a slight retardation during the summer months. In the evening, the barometer again rises, reaching a secondary maximum about 22h., and finally falls again to a secondary minimum at about 3h. As compared with the diurnal curve of Calcutta, the inequality of the day and night oscillations, as well as the amplitude of the double oscillation, is less over the sea than on the land. On the average of the whole year, the secondary or evening maximum is only 0.016 inch less than the principal or morning maximum; the difference being greatest in March, April and May, and least in July; while the secondary, or morning minimum, is only 0.016 inch above the principal or afternoon minimum. The following table gives the values of the diurnal maxima and minima:—

MONTHS.	1st min.	1st max.	2nd min.	2nd max.	Range.
January	—033	+049	—050	+035	099
February	—030	+048	—047	+030	095
March	—030	+048	—046	+028	094
April	—028	+048	—047	+025	095
May	—032	+048	—040	+022	088
June	—025	+041	—045	+030	086
July	—020	+032	—040	+028	072
August	—027	+044	—042	+028	086
September	—023	+042	—043	+023	085
October	—031	+048	—044	+030	092
November	—032	+045	—046	+034	091
December	—030	+044	—046	+031	090
YEAR	—02842	+04475	—04466	+02866	089

Comparing these with the maxima and minima of the diurnal oscillation on the equatorial Atlantic, it appears that the amplitude of the day range, over the Bay of Bengal, is 0.016 inch greater than over the Atlantic, while the night range is almost identical in the two regions. The following are the figures for the Atlantic equatorial region, for the year, as computed in the London Meteorological office:—

1st min.	1st. max.	2nd min.	2nd max.
—027	+036	—037	+029

¹ These differences are partly due to the fact that the Calcutta only is computed from observations at hourly intervals, that of the marine area from observations at intervals of 4 hours only. H.F.B.

The ratio between the amplitudes of the night and day oscillations, shewn in the above figures, may be approximately set down as follows:—

January . . . '69 : 1	May . . . '61 : 1	September . . '54 : 1
February . . . '63 : 1	June . . . '64 : 1	October . . . '66 : 1
March . . . '62 : 1	July . . . '66 : 1	November . . '73 : 1
April . . . '56 : 1	August . . '64 : 1	December . . '68 : 1

or, dealing with the ratio according to the method employed by Mr. Blanford in discussing Dr. Scully's barometric observations at Yarkand, *vis.*, dividing the second constant coefficient of the periodic formula by the first, the following figures are obtained:—

January . . . 3'43	May . . . 2'58	September . . 2'39
February . . . 2'81	June . . . 3'01	October . . . 2'97
March . . . 3'18	July . . . 3'00	November . . 3'63
April . . . 2'54	August . . 2'60	December . . 3'61

Yearly average 2'98.

Comparing these figures with the corresponding maximum and minimum values at some stations in India, we have—

Bombay.		Allahabad.		Calcutta.		Mid-Ocean.	
July	April	January	May	July	May	November	September
5'58	1'39	1'46	0'72	1'77	1'19	3'63	2'39

A noticeable feature in these amplitude ratios, and one which has apparently only been remarked in these mid-ocean observations, is the increase of the ratio which occurs in the months of April and September; coinciding with the two great atmospheric changes of the year.

Months.	1st min.	1st max.	2nd min.	2nd max.
January	3 hours 26 min.	9 hours 14 min.	15 hours 41 min.	21 hours 55 min.
February	3 " 23 "	9 " 8 "	15 " 42 "	22 " 0 "
March	3 " 17 "	9 " 36 "	15 " 54 "	21 " 41 "
April	3 " 5 "	9 " 45 "	16 " 0 "	21 " 32 "
May	3 " 7 "	9 " 32 "	15 " 56 "	21 " 35 "
June	3 " 34 "	9 " 27 "	15 " 53 "	22 " 2 "
July	3 " 38 "	9 " 26 "	15 " 48 "	22 " 1 "
August	3 " 35 "	9 " 10 "	15 " 51 "	22 " 20 "
September	3 " 12 "	9 " 20 "	15 " 51 "	22 " 49 "
October	3 " 31 "	9 " 18 "	15 " 46 "	22 " 9 "
November	3 " 32 "	9 " 15 "	15 " 42 "	22 " 0 "
December	3 " 10 "	9 " 23 "	15 " 41 "	21 " 32 "

The above table gives the epochs of the minima and maxima pressures computed by Dr. Jelinek's formula. From these hours means were obtained, from which it appears that, on the average of all the months, the epoch of the absolute minimum of the daily curve

occurs at 15 hours 49 min. (the range being 19 min.), and that of the secondary minimum at 3 hours 22 min. (the range being 33 min.), while that of the principal maximum occurs at 9 hours 22 min. (the range being 37 min.), and that of the secondary at 21 hours 53 min., the range being 37 min.).

• *Temperature.*—To obtain the temperature means for each month, the following method was employed. Each ship, entering the selected square, was followed in its course through the square, and its thermometric observations extracted; provided they covered an interval of 24 hours. If one day was spent in traversing the square, then the 6 four-hourly observations, commencing with 4 A.M., were utilised to obtain a mean; while if two entire days were so occupied, then the 12 four-hourly observations were employed to obtain a single mean value; and as, in the case of each month, not less than 30 of these sets of observations were used to obtain the average, each of the means given below represents at least 180 observations:—

Jan.	Feb.	Mar.	Apl.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
80°·8	81°·6	82°·4	83°·6	83°·2	82°·4	81°·8	82°·4	81°·3	81°·2	80°·7	81°·1

Yearly mean 81°·9.

The most striking feature of this series of figures is the uniformity of temperature which they show throughout the year, the total annual range (April + 1·7°, November—1·2°) being less than 3°. The nearest approach to this uniformity, among the stations of the Indian Meteorological Service, are:—

Nancowry with an annual range of	.	.	.	.	.	.	3·4°
Port Blair „ „ of	.	.	.	.	.	.	4·3°
Point de Galle „ „ of	.	.	.	.	.	.	3·9°

From the sets of four-hourly observations, employed in obtaining the monthly average temperatures, the probable diurnal march of temperature was obtained by means of Bessel's formula. The results are given in the following table:—

Hrs.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Mid-night.	-0·43	-1·33	-1·07	-1·00	-0·50	-0·40	-0·30	-0·03	-0·73	-0·77	-0·67	-0·93
1	-0·65	-1·44	-1·23	-1·21	-0·61	-0·56	-0·48	-1·14	-0·81	-0·88	-0·70	-1·19
2	-0·97	-1·45	-1·42	-1·45	-0·75	-0·75	-0·71	-1·23	-0·92	-1·04	-0·81	-1·43
3	-1·24	-1·39	-1·55	-1·65	-0·87	-0·92	-0·91	-1·25	-1·00	-1·19	-0·91	-1·57
4	-1·30	-1·30	-1·53	-1·70	-0·87	-0·97	-1·00	-1·17	-0·97	-1·27	-0·90	-1·53
5	-1·10	-1·19	-1·32	-1·55	-0·72	-0·87	-0·93	-0·95	-0·79	-1·22	-0·74	-1·30
6	-0·71	-1·02	-0·90	-1·22	-0·44	-0·64	-0·71	-0·64	-0·49	-1·04	-0·44	-0·88
7	-0·26	-0·75	-0·32	-0·77	-0·10	-0·36	-0·45	-0·28	-0·11	-0·74	-0·08	-0·25
8	+0·07	-0·33	0·33	-0·30	+0·20	-0·10	-0·20	+0·07	+0·27	-0·37	0·23	+0·17
9	+0·22	+0·21	+0·97	+0·14	+0·42	+0·10	-0·03	+0·36	+0·59	+0·05	+0·46	+0·63

Hrs.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.
10	+0°23	+0°80	+1°51	+0°50	+0°55	+0°24	+0°09	+0°59	+0°83	+0°47	+0°61	+0°98
11	+0°25	+1°33	+1°89	+0°92	+0°64	+0°37	+0°22	+0°81	+1°01	+0°87	+0°74	+1°23
12	+0°40	+1°70	+2°07	+1°30	+0°73	+0°53	+0°40	+1°03	+1°13	+1°23	+0°90	+1°37
13	+0°71	+1°85	+2°04	+1°67	+0°84	+0°73	+0°65	+1°26	+1°21	+1°52	+1°10	+1°42
14	+1°11	+1°78	+1°82	+1°95	+0°92	+0°92	+0°91	+1°43	+1°22	+1°67	+1°27	+1°40
15	+1°41	+1°56	+1°43	+2°05	+0°93	+1°03	+1°09	+1°48	+1°11	+1°65	+1°31	+1°28
16	+1°47	+1°27	+0°93	+1°90	+0°80	+1°00	+1°10	+1°37	+0°87	+1°43	+1°13	+1°07
17	+1°22	+0°96	+0°40	+1°49	+0°54	+0°81	+0°93	+1°07	+0°51	+1°05	+0°74	+0°78
18	+0°74	+0°65	+0°10	+0°92	+0°20	+0°51	+0°61	+0°64	+0°09	+0°58	+0°20	+0°45
19	+0°21	+0°34	+0°48	+0°31	+0°13	+0°19	+0°27	+0°16	+0°29	+0°11	+0°32	+0°01
20	+0°20	0	+0°73	+0°20	+0°37	+0°07	0	+0°27	+0°57	+0°27	+0°70	+0°13
21	+0°39	+0°38	+0°86	+0°54	+0°48	+0°22	+0°15	+0°59	+0°70	+0°51	+0°86	+0°34
22	+0°40	+0°76	+0°91	+0°74	+0°49	+0°28	+0°19	+0°79	+0°73	+0°63	+0°84	+0°52
23	+0°37	+1°10	+0°96	+0°86	+0°47	+0°32	+0°22	+0°93	+0°72	+0°70	+0°74	+0°71

Briefly summarised, this Table¹ shews that the average diurnal range of temperature is in—

January	2°77°	May	1°80°	September	2°22°
February	3°30°	June	2°00°	October	2°94°
March	3°62°	July	2°10°	November	2°22°
April	3°75°	August	2°73°	December	2°99°

Mean of twelve months 2°70°.

During the earlier months of the year, there is a decided increase in the amplitude of the diurnal range. In January it equals 2°7°, and in April 3°7°; but in May, probably owing to more frequent rain, there is a rapid fall, and the minimum range of the whole year is registered in this month.

Considering the smallness of the annual and diurnal range of temperature, and the comparatively large extent of the absolute range, it is evident that the thermometer varies more with temporary changes of weather than with the annual revolution of the seasons. As a proof of this, it may be mentioned that, in November, December and January, which are the coolest months of the year, the thermometer has risen as high as 90°, and, on the other hand the occurrence of a shower of rain, in April and May, not infrequently brings the temperature down to 75° or 76°.

Wind.—The wind observations have been discussed by two different methods. In the first instance, the percentages of frequency of the different wind directions have been obtained, and subsequently, from these figures, has been deduced the mean resultant. These results are given in the following table, which shews, with great distinctness, the reversal which the wind undergoes, in its change from the summer to the winter mon-

¹ The great variability of the diurnal oscillation in different months, as shown by this Table, and more especially the shifting of the epoch of maximum temperature, tend to throw doubt on the validity of the figures, as representing exactly the normal averages.—H. F. B.

soon, and *vice versa*. In the formation of the table, every wind, recorded within the area, has been employed; but the process of weighting, advocated in the marine publications of the London Office, has been adopted. This process consists in admitting no more than a single observation from the same ship, on the same day, and in the same one degree square. Thus adjusted, the observations give the following figures:—

Months.	N.	2	4	6	E.	6	4	2	S.	2	4	6	W.	6	4	2	Calm.	Resultant direction and percentage of prevalence.
	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	%	
January . . .	10.2	21.5	19.6	13.0	7.1	1.5	1.0	1.7	1.0	2.2	1.8	1.0	3.2	2.3	2.5	2.4	7.9	N. 36° E. 57
February . . .	13.7	17.6	24.2	8.9	7.1	2.7	2.2	1.1	1.4	0.7	0.5	0.9	4.1	1.9	2.5	5.1	5.4	N. 32° E. 61
March . . .	11.3	13.6	15.1	5.7	7.3	5.1	5.2	2.7	1.4	1.0	2.7	2.0	5.4	2.9	4.9	4.0	9.7	N. 29° E. 42
April . . .	2.7	2.7	5.2	3.1	7.7	6.2	6.2	3.8	8.0	7.0	7.4	6.7	8.3	4.4	4.4	3.8	12.4	S. 17° W. 15
May . . .	0.2	0.9	1.2	0.4	2.0	0.3	1.1	3.1	6.2	4.6	29.0	16.9	21.6	8.8	0.6	0.4	2.7	S. 61° W. 71
June . . .	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.3	6.9	15.8	31.9	29.8	13.6	0.3	0.4	0.0	0.0	S. 52° W. 90
July . . .	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.7	11.7	16.8	31.8	22.2	11.2	1.6	0.0	0.0	0.0	S. 44° W. 86
August . . .	0.0	0.0	0.0	0.0	0.0	1.2	0.8	7.0	16.0	16.0	19.1	17.0	20.0	0.4	0.2	0.0	2.3	S. 41° W. 79
September . . .	0.0	0.0	0.0	0.2	0.4	0.0	0.1	3.2	10.9	16.0	24.4	25.9	14.5	3.1	0.1	0.0	1.2	S. 49° W. 83
October . . .	0.4	0.0	0.0	0.0	0.4	0.3	0.9	2.9	7.5	8.3	17.1	26.2	21.2	8.8	2.7	0.8	2.5	S. 64° W. 76
November . . .	4.2	7.1	4.5	2.3	4.0	1.7	5.5	2.7	2.8	5.4	13.6	13.1	11.7	7.7	5.2	2.8	5.7	S. 79° W. 29
December . . .	10.0	17.0	10.5	6.5	2.3	2.2	3.8	1.0	0.3	0.3	1.4	6.8	11.0	6.8	7.8	6.6	5.7	N. 7° W. 43
Year . . .	4.3	6.7	6.7	3.3	3.2	1.8	2.2	2.9	6.2	7.8	15.1	14.0	12.2	4.1	2.6	2.2	4.6	S. 66° W. 30

In the first quarter of the year, the wind holds steadily from about north-east by north; but in April, when the maximum number of calms is recorded, there is a sudden shift and the resultant shews a direction only a few degrees west of south. The table of percentages shews, very clearly, the variable nature of the wind during April, and the struggle taking place between the approaching south-west monsoon and the remnant of the north-east current which has prevailed during the previous three months. From April onward, however, there is no doubt about the predominant wind; a very steady breeze, from between south-west and west-south-west, prevailing from May to September; the frequency in June being as high as 90 per cent. After September, the wind veers round more towards west, while, at the same time, there is a falling off in the percentage of frequency in the resultant direction, and an appearance of occasional northing. Very slight in October, this northing increases somewhat in November; and in December, the resultant direction is only a few degrees west of north.

A point of interest, in connection with the wind's direction, is the relation which exists between different directions and the elements of pressure and temperature. The following tables shew this. The first gives the average height of the barometer, with winds from the 8 principal points of the compass and during calms. The results are not

wholly satisfactory, owing to the insufficiency of the observations in many cases: these numbers are shown in brackets.

DIRECTION OF WIND.	FOR ALL THE YEARS.											
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
North	(90) 29°9'09	(141) 892	(125) 875	(44) 858	(2) 935	...	...	...	...	(9) 849	(21) 906	(74) 878
North-east	(203) 29°9'26	(174) 894	(172) 893	(34) 836	(3) 834	...	...	...	...	(1) 976	(48) 906	(76) 897
East	(102) 29°9'12	(73) 906	(89) 893	(37) 843	(9) 813	...	...	...	(1) 936	(3) 939	(30) 904	(31) 899
South-east	(12) 29°9'20	(23) 892	(73) 891	(57) 866	(7) 870	...	...	(3) 898	(1) 30°0'08	(6) 29°9'42	(25) 899	(24) 907
South	(19) 29°9'12	(21) 896	(26) 897	(65) 851	(25) 860	(13) 859	(36) 845	(41) 876	(84) 910	(72) 931	(18) 898	(6) 889
South-west	(25) 29°9'10	(6) 862	(21) 897	(65) 857	(60) 841	(60) 849	(54) 869	(56) 883	(123) 895	(120) 887	(45) 896	(14) 882
West	(24) 29°9'04	(22) 868	(54) 864	(60) 872	(50) 815	(34) 855	(34) 834	(47) 873	(121) 873	(166) 878	(59) 859	(61) 887
North-west	(20) 29°8'67	(23) 878	(66) 886	(42) 844	(19) 842	...	...	(2) 855	(3) 832	(39) 887	(43) 906	(49) 893
Calms	(55) 29°9'03	(47) 889	(73) 920	(78) 882	(12) 881	...	...	(10) 906	(7) 940	(44) 842	(33) 900	(25) 923

The next table gives the average temperature experienced with the different wind directions:—

DIRECTION OF WIND.	FOR ALL THE YEARS.											
	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
North	(79) 80°3	(133) 81°3	(106) 82°1	(39) 84°7	(2) 85°0	...	...	...	...	(8) 80°8	(19) 82°1	(66) 80°2
North-east	(195) 81°2	(196) 81°8	(153) 82°4	(35) 85°3	(3) 84°0	...	...	...	...	(1) 76°0	(39) 81°4	(62) 80°9
East	(95) 81°1	(70) 82°2	(68) 83°0	(32) 84°6	(9) 84°3	...	...	...	(1) 83°0	(3) 82°7	(23) 81°4	(29) 82°3
South-east	(9) 82°0	(15) 82°5	(68) 82°4	(58) 84°3	(5) 83°6	...	...	(3) 83°3	(1) 82°0	(6) 80°2	(17) 82°0	(24) 80°2
South	(13) 81°1	(17) 81°7	(25) 82°9	(55) 84°5	(24) 84°0	(14) 82°4	(36) 82°4	(32) 84°9	(74) 82°0	(62) 80°8	(14) 81°6	(6) 79°2
South-west	(22) 80°1	(4) 80°5	(22) 80°8	(58) 84°1	(28) 83°8	(50) 82°7	(48) 82°3	(34) 82°1	(124) 81°6	(114) 81°1	(47) 81°8	(14) 80°6
West	(25) 79°3	(23) 82°2	(40) 82°2	(62) 84°4	(34) 83°9	(49) 82°5	(35) 81°6	(25) 81°0	(99) 81°3	(153) 80°3	(63) 81°4	(59) 80°4
North-west	(22) 80°2	(22) 80°1	(56) 81°8	(35) 84°8	(16) 83°8	(1) 79°0	...	(1) 83°0	(3) 80°0	(29) 80°7	(33) 81°7	(41) 79°7
Calms	(44) 79°4	(42) 83°3	(65) 81°7	(65) 85°2	(12) 84°6	(1) 84°0	...	(1) 82°0	(15) 81°1	(40) 81°4	(31) 81°4	(22) 80°4

Force of wind.—The average force of the wind under the different directions, for each month and for the year, is as follows:—

Months.	N.	2	4	6	E.	6	4	2	S.	2	4	6	W.	6	4	2	Month
January	3.0	3.2	3.6	3.2	2.8	2.4	2.4	2.6	2.5	1.9	2.4	2.4	3.2	2.6	2.9	2.9	2.7
February	2.6	3.4	3.1	3.3	3.3	2.8	2.5	1.7	2.5	1.0	2.8	2.8	3.7	3.9	1.9	2.7	2.8
March	2.2	2.5	2.9	2.5	2.4	2.2	2.0	1.9	2.3	1.7	2.2	2.4	3.0	2.5	2.2	2.6	2.3
April	1.8	1.8	2.4	2.0	2.2	2.3	2.7	2.3	2.6	2.3	7	2.8	2.9	2.9	2.2	1.7	2.4
May	1.0	3.0	1.0	...	3.7	...	1.7	1.7	2.2	2.5	3.9	3.7	4.4	4.7	1.0	1.5	2.6
June	...	...	...	...	...	...	...	2.0	3.9	3.7	4.8	5.2	6.1	...	2.0	...	4.0
July	...	...	...	...	...	...	...	3.2	3.4	4.1	4.9	5.6	5.2	...	...	...	4.4
August	...	...	...	...	...	3.0	3.5	3.4	3.0	3.8	4.5	5.1	4.7	6.0	1.0	...	3.8
September	...	...	...	4.0	1.0	...	3.0	3.4	3.5	3.8	4.0	4.9	5.2	6.0	...	...	3.8
October	2.5	...	...	...	2.0	3.0	3.3	3.5	2.7	3.7	3.8	4.5	4.5	4.3	3.4	2.0	3.3
November	2.9	3.5	3.2	3.0	1.6	3.4	3.2	3.0	3.1	2.9	3.1	4.2	3.0	2.5	2.7	2.3	3.0
December	3.5	3.9	3.2	2.4	2.0	3.1	2.4	4.0	2.0	4.0	3.7	3.9	3.7	2.9	3.0	3.1	3.2
Year	2.4	3.0	2.8	2.9	2.3	2.8	2.7	2.7	2.8	3.0	3.6	4.0	4.1	3.8	2.2	2.4	3.2

The final figures of this table shew that the maximum wind-force, throughout the year, occurs when the wind's direction is about west. Further, as the final column shows, the months of the strongest winds are those in which west winds most predominate, *viz.*, June and July.

The number of gales, recorded within the area here considered, is very small; except in October, the force of the wind has not at any time exceeded force 9 of the Beaufort scale. In the whole of the 25 years under discussion, the wind reached the force of a gale the following number of times, in each of the 12 months of the year:—

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
0	0	1	0	3	2	2	0	1	2	1	1

Calms.—In June and July, *i. e.*, when the summer monsoon is in full force, calms are entirely absent; but in all the remaining months they are more or less frequent. This frequency is greater in those months in which the north-east wind is predominant, than in those in which the south-west prevails; and reaches its maximum in April, or at the epoch of change from the winter to the summer monsoon. At the reversal of these conditions the phenomenon of calms is much less marked.

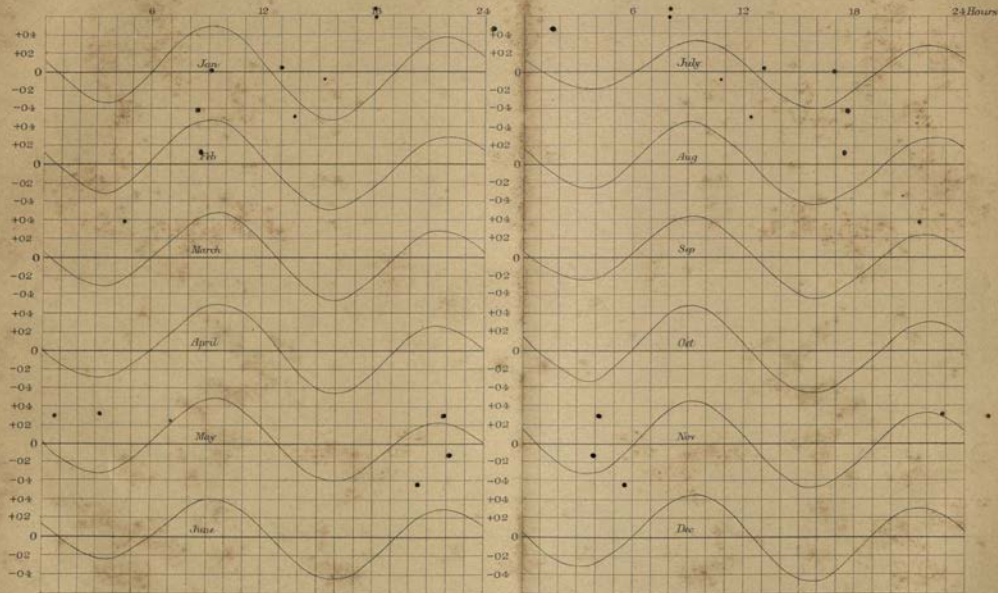
APPENDIX.

Table I.—Rectangular co-ordinates of the constants in the periodical formula for the diurnal variation of pressure at North Lat. 0° - 10° and East Long. 80° - 90° .

	$U' \sin' u'$	$U' \cos u'$	$U'' \sin u''$	$U'' \cos u''$	$U''' \sin u'''$	$U''' \cos u'''$
January	+0007	+0121	+0120	-0398	+0017	0
February	-0002	+0136	+0105	-0367	+0023	0
March	-0047	+0110	+0123	-0358	-0017	0
April	-0072	+0124	+0122	-0244	-0037	0
May	-0085	+0107	+0102	-0338	-0010	0
June	+0010	+0116	+0130	-0323	0	0
July	+0037	+0092	+0110	-0277	-0003	0
August	+0007	+0133	+0123	-0323	+0037	0
September	-0022	+0136	+0095	-0315	-0007	0
October	-0007	+0127	+0120	-0358	+0033	0
November	+0015	+0107	+0122	-0372	+0020	0
December	-0017	+0104	+0090	-0370	-0017	0

Table II.—Constant co-efficients of the periodical formula computed from Table I.

	Mean.	U'	u'	U''	u''	U'''	u'''
January	29° 9' 15"	0121	3° 10'	0416	163° 14'	0017	90° 0'
February	895	0136	359° 17'	0381	164° 1'	0023	90° 0'
March	892	0118	336° 50'	0379	161° 0'	0017	270° 0'
April	861	0143	329° 59'	0364	160° 29'	0037	270° 0'
May	842	0137	321° 29'	0353	163° 15'	0010	270° 0'
June	857	0116	4° 57'	0249	158° 6'	0	0
July	852	0099	21° 40'	0298	158° 21'	0003	270° 0'
August	878	0133	2° 53'	0346	159° 7'	0037	90° 0'
September	892	0137	350° 55'	0329	163° 12'	0007	270° 0'
October	886	0127	356° 59'	0378	161° 28'	0033	90° 0'
November	892	0108	8° 0'	0392	161° 54'	0020	90° 0'
December	893	0105	350° 52'	0380	166° 19'	0017	270° 0'



DIURNAL VARIATION OF PRESSURE. N. INDIAN OCEAN.

between 0° and 10° N. lat. and between 80° and 90° E. long.

*IV.—The False Point Cyclone of September 22nd, 1885. By ALEXANDER PEDLER,
Officiating Meteorological Reporter to the Government of Bengal.*

INTRODUCTION.

THE present paper is written with the intention of giving a full history of the meteorological conditions, which attended the formation, progress, and disappearance of the disastrous cyclone, which visited Orissa in September 1885, and the centre of which struck False Point on the morning of the 22nd, causing a large destruction of life and property. The cyclone was a comparatively small one; the diameter of that part, where the wind was of great force, being not more than 100 to 120 miles; while the central calm had a diameter of probably not more than 8 or 9 miles. It was a storm of great interest from a meteorological point of view, for it was generated earlier in the season than is usual with storms of such fierceness in the Bay of Bengal; it was also formed under conditions somewhat different from those usually obtaining; and when formed, it advanced with rather unusual swiftness in almost a north-westerly direction. Owing to its smallness, and to the rapidity of its advance, the cyclone gave very little warning of its existence, or of the direction of its advance, and hence the working out of this storm is of considerable value, to test the weak points in the present system of judging weather conditions in the Bay of Bengal, and of forecasting storms.

The storm also affords good evidence of the antecedent conditions, which are probably essential to the formation of cyclones generally; the recorded observations support, in a very pronounced manner, the "condensation theory" of the generation of cyclones.

It appears that when conditions were rather, though not entirely, favourable to the formation of a cyclone, and when over that part of the Bay where the storm subsequently formed, the horizontal air motion was very feeble and variable, a slight local fall of pressure took place, attended with very heavy rain; and this seems to have determined the formation of the storm; within two days the cyclone had formed. At first it was feeble, but with the continuance of heavy rainfall, it afterwards gathered strength and fierceness in its advance. Further, the history of this storm appears to lend considerable support to the view, that cyclonic storms may be formed, and may travel at different levels of the atmosphere; and from the evidence available in this case,

it would appear, that this storm was mainly confined to the lower levels of the atmosphere.

In order to treat of the history and conditions of the storm fully, and to bring out the above points, it is proposed to discuss the storm under the following heads :—

Summary of the meteorology of India during the earlier part of the monsoon, or the rainy season of 1885 in Upper India.

Summary of the meteorology of India, for the period antecedent to the formation of the False Point cyclone, *i.e.*, for the earlier part of September 1885.

Detailed meteorology of the Bay of Bengal and Upper India, for the period of formation, advance, and determination of the cyclone, *i.e.*, from September 16th to September 24th, 1885, inclusive.

The storm-wave accompanying the cyclone, and the destruction caused by the action of the cyclone generally.

The recorded barometric pressures.

The recorded wind directions and velocities.

General remarks as to the formation of the storm, and discussion of its bearing on cyclone theories generally.

SUMMARY OF THE METEOROLOGICAL CONDITIONS OF INDIA DURING THE EARLIER PART OF MONSOON OR RAINY SEASON OF 1885.

The rainy season of Upper India in 1885, set in at about the usual period. Both branches of the monsoon current, the one blowing from the Arabian Sea, the other from the Bay of Bengal, appear to have been of considerable strength; and though the Bombay branch was weak at first, it afterwards brought up heavier rain. Certain parts of India, therefore, during the earlier part of the monsoon, received a deficient rainfall; but the deficiency was, to a great extent, compensated by heavier falls in other districts, or in the same districts at later periods. Of the two branches of the monsoon current, that from the Bay of Bengal appears to have been comparatively stronger, and up to the end of July, the area fed by this branch, as a rule, received a rainfall very considerably in excess of the normal. In August again, the Bombay branch of the monsoon was comparatively weak, and the Bengal current strong, and rainfall was seriously deficient over parts of the peninsula. In Khandesh and the Bombay Deccan, it was scarcely half the normal average, and further southward in Mysore, at Bangalore and other stations, there was a similar deficiency.

On the other hand, over the area which receives its rainfall principally from the Bengal branch of the monsoon, the fall was generally in excess; the excess in some places being very considerable, and at some stations, such as Roorkee, more than double the normal amount. The heavy rainfall over the part of Northern India affected by this current was, to a great extent, due to the fact that numerous small cyclonic whirls, generally of low intensity, were formed, several of which travelled up the Gangetic plain in a north-westerly direction, and then affected the weather right up to the Punjab; others passed over Behar into the North-West Provinces, and their effect was in every case to give heavy rainfall.

The following table will show the average distribution of rainfall in August and the

difference therefrom of the actual fall in 1885, as obtained from the telegraphic reports received by the Meteorological Department, Government of India:—

DISTRICTS.	Average Rain-fall in August.	Difference from the average in August 1885.
Punjab, West	5'74	+0'37
„ East	8'49	+3'14
North-Western Provinces, Trans-Gangetic	12'74	+6'30
North-Western Provinces, Cis-Gangetic	8'89	+4'58
Behar	9'90	+7'00
Northern Bengal	17'60	—0'33
Assam, Cachar	14'42	—3'66
Lower Bengal, Chutia Nagpur	14'22	+5'64
Orissa, Northern Circars	8'63	—3'45
Central Provinces, South	12'26	—1'97
Berar, Khandesh	5'99	—1'36
Rajputana, Central India, Saugor and Nerbudda	10'98	+1'85
Sind, Cutch	2'29	+1'57
Guzerat	8'34	+3'69
Konkan	14'92	+3'38
Deccan, Hyderabad	5'83	—0'66
Malabar	19'69	—1'32
Mysore, Bellary	4'23	—2'07
Canatic	3'33	—1'83
Burma	22'42	+7'55
Ceylon	4'78	—2'15

Judging by the rainfall of Bengal, Behar and the North-West Provinces in August, it would seem that a great increase in the strength of the Bengal monsoon current had taken place since the previous month. Over the central parts of Bengal, *i.e.*, excluding Orissa on the one side and North Bengal on the other, the rainfall of August was excessive. As has been already observed, this was chiefly caused by a succession of feeble barometric depressions, which followed one another so rapidly that there was scarcely any marked interval of diminished rainfall between them. No less than nine of these depressions or cyclonic whirls passed over Bengal in August. Three were formed in Central Bengal, and moved towards Chutia Nagpur and South Behar, two in South and South-East Bengal, and passed through South-West and Central Bengal into Chutia Nagpur; two at the head of the Bay of Bengal, and passed through Western Bengal into Chutia Nagpur; one off the Orissa coast, which also passed through Orissa into Chutia Nagpur; and the ninth was of feeble depression formed over South Behar. As all these depressions brought with them heavy rain, the rainfall in South-West Bengal, South Behar and Chutia Nagpur was excessive; North Behar and East Bengal also received falls in excess of the normal. Orissa received an average, and North Bengal a slight deficiency.

It will give some idea of the extraordinarily heavy rainfall in August in Bengal, when it is stated that at Cox's Bazar (East Bengal) a rainfall of 36·7 inches in excess of the normal average (26·76 inches) was recorded, and at Jehanabad, in the Hooghly district, the excess amounted to 32·2 inches. Again, the fall in the Midnapore division was about 20 inches in excess of the normal average, which is not less than 13 inches. In the Chittagong district, the rainfall was 21 inches in excess of the normal fall of 21·62 inches; and in the 24-Pergunnahs, Bankoorah and Saugor Island districts, the excess was about 15 inches. The following small table will show how extraordinarily heavy was the rainfall in Bengal during parts of August. In this table the amounts are expressed as percentages of the normal :—

Mean rainfall of each Meteorological Division of Bengal expressed as a percentage of the normal average for the corresponding period.

DISTRICT.	1st week, August 1st to 7th, 1885.	2nd week, August 8th to 14th, 1885.	3rd week, August 15th to 21st, 1885.	4th week, August 22nd to 28th, 1885.	For the whole month August 1885.
Orissa	9	63	143	95	100
South-West Bengal	150	89	176	404	185
East Bengal	107	30	192	161	116
North Bengal	61	67	103	58	71
North Behar	87	133	100	105	106
South Behar	143	105	202	235	161
Chutia Nagpur	169	48	210	194	152

The rainfall over Bengal having thus been exceptionally heavy, it might perhaps be expected, that the strength of the Bengal branch of the monsoon, as measured by the wind velocities at the head of the Bay, would have been proportionately great; but this seems to have been scarcely the case. Thus, the mean daily wind movement at False Point, during August, was about 245 miles, against the normal average of about 215 miles; at Cuttack, 62 miles, against the normal movement of 66 miles; at Saugor Island, 345 miles, against the normal of about 270 miles; at Jessore, 166 miles, against the average of 98 miles; at Dacca, 125 miles, against the normal of 152 miles, and at Chittagong, 144 miles, the normal amount being 145 miles. It would, therefore, appear that at the western stations, on or near the coast, the wind movement, which is our only criterion of the strength of the monsoon, was a little greater than usual, while, at the eastern stations, it was a little lower than the general average. These small differences will certainly not account for the largely increased rainfall, and it would appear that the only possible explanation of the fact is that the depth of the current blowing over Bengal was greater than usual, though its velocity was about the normal.

SUMMARY OF METEOROLOGY OF INDIA FOR THE PERIOD ANTECEDENT TO THE FORMATION OF THE FALSE POINT CYCLONE, *i.e.*, FOR THE EARLIER PART OF SEPTEMBER 1885.

The meteorology of India in the earlier part of September began, as usual, to change rather rapidly. The area of the rainfall brought up by the two branches of the monsoon began to contract, and both branches became weaker and less steady than they had been in August. Beyond a few showers, no rain of importance fell in the Punjab after the 7th of September. Over the greater part of the North-West Provinces, rain was also practically absent from the 7th up to about the 21st of the month, and the Central Provinces received but little rain during greater part of the same period. It was thus clear that the area fed by the Bengal branch of the monsoon had contracted very rapidly.

In Bengal, however, during the early part of September, rain continued falling more plentifully than usual. The general mean rainfall of the whole of Bengal, for the first ten or eleven days of September, was about fifty per cent. in excess of the average fall of past years for the same period. It was particularly heavy in Behar, South-West Bengal and East Bengal; while North Bengal and Chutia Nagpur received smaller amounts, and Orissa a comparatively small fall only. In this last province, from 4th to 11th of September, the fall was particularly small, amounting to only about a seventh of the usual quantity. Not only was the rainfall of Bengal, during the early part of September, heavy as compared with the average of past years, but absolutely it was very considerable. This is seen in the following table, wherein the mean rainfalls in the seven meteorological districts of Bengal are given for the two weeks, 28th August to 4th September, and September 4th to 11th, 1885:—

Mean Rainfall in each District in Bengal for first two weeks of September.

DISTRICT.	August 28th to September 4th, 1885.	September 4th to 11th, 1885.
Orissa	2'60 inches	0'41 inches.
South-West Bengal	3'35 "	3'67 "
East Bengal	3'65 "	7'14 "
North Bengal	5'22 "	3'26 "
North Behar	5'27 "	3'64 "
South Behar	4'43 "	4'73 "
Chutia Nagpur	3'20 "	1'90 "

Hence, disregarding the slight inequalities of the areas of the several districts, the mean rainfall of the province for the week, August 28th to September 4th, amounted to 3'96 inches, and that for the week, September 4th to September 11th, to 3'54 inches. This gives a general average of more than half an inch of rain per day, for every part of the province, for the period in question.

It is clear, then, that nothing like a break in the rains had occurred in Bengal, during the fortnight ending September 11th, that is, up to a date only ten days preceding that at which the cyclone reached the coast of Orissa.

Although, then, the area of rainfall in Northern India had rapidly contracted during the earlier part of September, in Bengal itself the monsoon continued to give abundant rainfall to the greater part of the province.

On the 10th and 11th September, however, the rainfall was decidedly less general, and lighter than it had previously been, and this falling off became even more strongly marked on the subsequent day. The decrease was indeed very noticeable on the 12th of September, and it began, as usual, over the north-western portion of the province, *i.e.*, in Behar and adjacent districts. This is shown in the following table, which gives the average of the rainfall recorded at all the stations, in each of the Meteorological Divisions of Bengal, for the 24 hours from 6 P.M. of the 11th September to 6 P.M. of the 12th, 1885:—

DISTRICT.	Number of Stations from which average is derived.	Average rainfall of District in inches.
Orissa	20	0'07
South-West Bengal	59	0'07
East Bengal	36	0'06
North Bengal	33	0'47
North Behar	24	0'03
South Behar	37	0'09
Chutia Nagpur	26	0'17

This shows that an average of only 0'14 inch fell over the whole province on the 12th, and on this day, therefore, a distinct break in the rains set in over a great part of the province of Bengal; for, except in parts of North Bengal and Chutia Nagpur, the reported rainfall was insignificant. Conditions, to a certain extent similar, obtained on the following day, when South Behar and Chutia Nagpur were practically rainless, and only light showers fell in Orissa and in South-Western and Eastern Bengal. In the northern districts, however, the rainfall was decidedly heavier and more general. This is shown again in the following table, which gives the rainfall in each of the Meteorological Districts of Bengal from 6 P.M. of the 12th to 6 P.M. of September 13th, 1885.

DISTRICT.	Number of Stations from which average is derived.	Average Rainfall of District for September 13th in inches.
Orissa	20	0'23
South-West Bengal	59	0'21
East Bengal	36	0'21
North Bengal	33	0'83
North Behar	24	0'41
South Behar	37	0'01
Chutia Nagpur	26	0'08

This may be said to be equivalent to a general rainfall of 0'28 inch over the whole province.

At this time the wind current blowing over the province was rather feeble and the wind directions were a little irregular, but, on the whole, the conditions were fairly normal for September.

This break in the rains, if it can be called such, was of very slight duration, and only very partial, for on the 14th instant rain again began to fall in moderate amounts in Orissa, South-West Bengal and East Bengal, while it continued general in North Behar. This is shown by the table below, which gives the average rainfall in the various districts for September 14th, 1885 :—

DISTRICT.	Number of Stations from which average is derived.	Average Rainfall of District for September 14th, 1885, in inches.
Orissa	20	0'47
South-West Bengal	59	0'35
East Bengal	36	0'69
North Bengal	33	0'09.
North Behar	24	0'71
South Behar	37	0'26
Chutia Nagpur	25	0'12

The average rainfall over the whole province, on this day, was therefore equal to 0'38 inch. Now the normal daily rainfall over the whole province of Bengal for September is only 0'33 inch, and therefore it cannot be said that there was any deficiency.

Notwithstanding that rain was fairly abundant on this day, the observations which were taken at the meteorological stations round the Bay of Bengal show that the conditions over the Bay were beginning to be a little disturbed. The observations of wind directions, at 10 A.M. of this day at the stations in the north-west angle of the Bay, showed a decided indraught towards the sea area, and on the following day a distinct, but very feeble, barometric depression appeared at the head of the Bay, the centre of which lay only a short distance to the south-east of Saugor Island. Around this, the winds were cyclonic in direction, but very light in force. The indraught towards the depression was feeble, and it scarcely influenced the rainfall of Bengal, for on this day it was almost equal to the normal amount for September. This is shown in the following table which gives the mean rainfall of September 15th, 1885 :—

DISTRICT.	Number of Stations from which average is derived.	Average rainfall of District for September 15th in inches.
Orissa	20.	0'61
South-West Bengal	59	0'39
East Bengal	36	0'40
North Bengal	33	0'32
North Behar	24	0'07
South Behar	37	0'17
Chutia Nagpur	25	0'12

This gives an average fall over the whole province of 0·30 inch, which is very nearly equal to the normal September daily average of 0·33 inch.

During the afternoon and night of the 15th, the small depression, above noticed, advanced in a north-westerly direction, and by the morning of the 16th was well inland, and its centre nearly midway between Calcutta and Burdwan. With its advance, inland, weather conditions became almost normal, as will be shown in the detailed description of the meteorology of the days immediately preceding the cyclone. This will now follow:—

DETAILED METEOROLOGY OF THE BAY OF BENGAL AND OF NORTHERN INDIA DURING THE FORMATION, ADVANCE, AND DETERMINATION OF THE CYCLONE, *viz.*, FROM SEPTEMBER 16TH TO 24TH INCLUSIVE.

The period which has now to be dealt with is that immediately preceding the formation of the cyclone, and it will be desirable to examine minutely the meteorology of India and of the Bay of Bengal for each successive day. It has previously been shown that, certainly up to the evening of September 15th, the meteorological conditions were more or less normal in character; also, that the area reached by the Bengal branch of the monsoon had contracted in the usual manner at the beginning of September; and that there had been no distinct break in the rains in Bengal, where the monsoon current was still giving about the normal amount of rain daily. In fact, during the earlier part of the month, the amount of rain falling in Bengal was decidedly heavier than usual.

16th of September.—The following observations, taken on the 16th September at the principal inland stations of Northern India, and at the principal coast stations round the Bay of Bengal, show the conditions over the land area for this day at 10 A.M.:—

STATIONS.	Barometer reduced to 32° and sea level.	Variation from normal pressure for September.	Wind direction.	Wind velocity in miles per hour for previous 24 hours.	Normal velocity, September, miles per hour.	Temperature.	Cloud proportion.	Rainfall in inches.	WEATHER REMARKS.
Lahore . . .	29·853	+·131	N	4	2·0	81·2	10	<i>Nil</i>	Overcast.
Delhi . . .	29·827	+·097	W	3	3·9	87·2	0	<i>Nil</i>	Fine clear weather.
Lucknow . . .	29·809	+·073	E	3	2·7	90·1	0	<i>Nil</i>	Fine clear weather.
Ajmere . . .	29·814	+·057	NW	8	4·7	86·8	1	<i>Nil</i>	Fine weather.
Allahabad . . .	29·811	+·073	W	?	2·7	89·7	1	<i>Nil</i>	Fine weather.
Patna . . .	29·838	+·086	E	2	3·0	85·6	6	<i>Nil</i>	
Nagpur . . .	29·857	+·085	Calm	3	4·7	86·2	8	<i>Nil</i>	Fine weather.
Bombay . . .	29·976	+·107	E	9	12·0	81·5	7	1·24	
Nancowry ¹ . . .	29·889 ²	—·044 ²	SW	3	9·6	86·0	5	<i>Nil</i>	Fine weather.
Port Blair . . .	29·987	+·090	SW	6	10·3	83·3	6	0·08	Cloudy.
Diamond Island . . .	29·974	+·116	S	4	6·8	82·4	6	0·03	Cloudy.
Bassein . . .	29·947	+·082	SSW	3	3·5	83·7	7	0·08	Cloudy.
Rangoon . . .	29·969	+·085	WSW	3	4·2	83·1	8	0·36	Passing showers. ³
Thayetmyo . . .	29·939	+·107	SE	2	5·0	85·1	5	<i>Nil</i>	Dark and gloomy.

¹ See note on next page.

STATIONS.	Barometer reduced to 32° and sea level.	Variation from normal pressure for September.	Wind direction.	Wind velocity in miles per hour for previous 24 hours.	Normal velocity, September miles per hour.	Temperature.	Cloud proportion.	Rainfall in inches.	WEATHER REMARKS.
Akyab . . .	29'939	+ '105	ESE	2	3'0	85'4	6	0'14	Cloudy.
Chittagong . .	29'914	+ '094	SE	4	4'5	79'2	10	0'64	Cloudy.
Dacca . . .	29'857	+ '083	SSE	3	4'6	80'9	10	0'60	
Calcutta . . .	29'837	+ '078	SE	2	4'6	81'0	10	0'06	Dull overcast.
Saugor Island .	29'839	+ '074	SSW	5	9'4	80'4	9	4'99	Sea smooth.
Cuttack . . .	29'862	+ '100	SSW	1	2'6	83'5	10	1'07	.....
False Point . .	29'862	+ '098	WSW	3	7'7	80'3	10	Nil	Sea rough.
Gopalpur . . .	29'860	+ '103	Calm	3	8'5	82'0	9	Nil	Sea very smooth.
Vizagapatam . .	29'881	+ '118	W	0	2'3	83'5	10	0'20	
Masulipatam . .	29'880	+ '060	WNW	5	?	86'0	8	Nil.	
Madras . . .	29'951	+ '100	WSW	5	6'7	80'5	8	0'51	
Negapatam . . .	29'970	+ '089	SW	1	5'5	85'0	7	0'36	
Trincomalee ¹ . .	29'860?	- '024?	SW	?	15'5	?	6	Nil.	
Galle . . .	30'002	+ '048	WNW	7	8'5	82'5	7	Nil.	
Colombo . . .	30'006	+ '050	WSW	6	8'4	85'0	4	0'17	Dark ; gloomy.

¹ It is to be regretted that the barometric observations at both Trincomalee and Nancowry made during the period of the False Point cyclone are untrustworthy.

The daily registers of pressure at Nancowry in particular at this period show that the barometric observations were most carelessly taken. In fact, the afternoon observations made on this day, 16th September, prove that the pressure was probably about a tenth of an inch higher than is above shown.

The main features of interest in the Meteorology of India as shown in the above land observations appear to be,—

First that, over a very large area, pressure was practically uniform ; thus, at Lahore on the north the reduced barometric reading was 29'853 inches ; at Dacca on the east 29'857 inches ; at Nagpur in the west 29'857 inches, and in the south at Masulipatam 29'880 inches. These pressures are practically equal, and they illustrate the condition prevailing from Lahore to Masulipatam and from Nagpur to Dacca.

As examples of stations within this area, may be cited Lucknow, where the pressure was 29'809 inches, Allahabad 29'811 inches, and Patna 29'838 inches.

On either side and to the south of this large area of uniform pressure, higher pressures were recorded. This is shown by the observations on the Arakan and Pegu coasts and at the Andaman Islands, which varied from 29'937 inches at Akyab to 29'987 inches at Port Blair ; while, on other sides, Bombay recorded 29'976 inches, Madras 29'951 inches, Galle 30'002 inches and Colombo 30'006 inches.

It would also appear that, over almost the whole of India, pressure, was considerably above the normal ; and that, for the most part, this excess was almost uniform. Thus, while, in the extreme north-west at Lahore, it amounted to 0'131 inch, at Diamond Island it was 0'116 inch, at Bombay 0'107 inch, and at Madras 0'100 inch. At stations in the centre of the large area of uniform pressure, it varied from about 0'07 inch to 0'08 inch.

A moderately high temperature prevailed at this time over the whole of India. Except at Chittagong, which registered a temperature of 79.2° at 10 A.M., on this day, no station recorded less than 80° , while the majority ranged from 82° to 86° , and at Lucknow even the 10 A.M. temperature was 90.1° .

Another point which comes out strongly in the above table, is the comparative lightness of the winds. Out of the whole of the stations included in the table, only three, in North-Western India, recorded wind velocities equal to or above the normal; the remaining stations, and particularly those round the coast of the Bay of Bengal, reported them, in many instances, only half as large as usual. The only exceptions to this rule are at the Ceylon stations, where the wind movement was nearly, though not quite equal, to the normal. On the whole, the wind directions, on this day, did not deviate much from the normal directions; but in Upper India they were more or less variable. In Southern Bengal, the directions were slightly influenced by the very feeble barometric depression, which, as stated previously, had advanced from the south-east of Saugor Island, and the centre of which was between Calcutta and Burdwan. This depression, however, was so slight, that its effect was only just perceptible. Thus, at a few stations in Chutia Nagpur and South-West Bengal, the winds were north-easterly; but these were purely local, and in no way connected with the cyclone under discussion. Generally speaking, at the coast stations in the Bay of Bengal, the directions were westerly and south-westerly, while over Bengal itself they were southerly at the southern stations, south-easterly in East Bengal, and easterly at the northern stations; in other words, such as are normal for the time of year.

Rainfall was entirely absent from Upper India on this day, but notwithstanding that the wind current blowing over Bengal was so much lighter than usual, it continued to give moderate rain to Orissa, South-West Bengal, East Bengal and North Bengal; rain had practically ceased in Behar and Chutia Nagpur. This is shown in the following table, wherein, as before, the average rainfall of the 16th is given for each Meteorological District of Bengal:—

DISTRICT.	Number of Stations from which average is derived.	Average rainfall of District for September 16th in inches.
Orissa	20	0.31
South-West Bengal	59	0.49
East Bengal	36	0.99
North Bengal	33	0.45
North Behar	24	0.04
South Behar	37	0.11
Chutia Nagpur	25	0.06

This would be equivalent to a general average of 0.35 inch all over the province, and, as already stated, the normal daily fall for September is only 0.33 inch. The total fall on this date was, therefore, quite equal to normal in Bengal.

Meteorology of the Bay of Bengal on the 16th September 1885.—The observations of this date which have been received from ships navigating the Bay of Bengal, and the sea to the south of it, are contained in the following table:—

16th September 1885.

NAMES OF SHIPS.	POSITION AT NOON.		Barometer reduced and corrected as nearly as possible for 10 A.M.	Wind.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Goa, S.S.</i>	6° 51' N.	81° 36' E.	29° 80"	4 A.M., WNW 8 A.M., NNW Noon, S 4 P.M., SSW 8 P.M., SSE Midnight, NW	2 2 2 2 4	Smooth sea and cloudy throughout. Current <i>nil</i> .
<i>Brindisi, S.S.</i>	17° 49' N.	84° 37' E.	29° 88"	4 A.M., variable 8 A.M., SWly Noon, SWly 4 P.M., SWly 8 P.M., SWly	1 2—3 2—3	Light airs. Moderate breeze. Current finished at about noon. Southerly swell.
<i>Lactura</i>	19° 54' N.	87° 36' E.	29° 80"	Noon?	4	Clear weather, with passing cumulus clouds.
<i>Britannia</i>	10° 19' N.	86° 58' E.	30° 06"	Noon, SSW to SW S	6	Fine weather.
<i>Barque Rollo</i>	4° 51' N.	87° 43' E.	29° 95"		Mde- rate.	Moderate south breezes, and fine weather throughout.
<i>Barque Cynosure</i>	8 A.M. 5° 27' N.	87° 48' E.	29° 92"	8 A.M., SSW Noon, WSW 3 P.M., SW	" " "	Moderate breeze and clear and fine. Moderate wind and cloudy. " wind and clear weather.
<i>Schooner Kunt Alfonso.</i>	6° 51' N.	84° 22' E.	?	W	Fresh	A.M. fresh westerly breeze; cloudy with rain. P.M. wind SW.
<i>Calcutta</i>	3° 4' N.	87° 40' E.	29° 97"	Noon, SSE to SW	*	Weather sultry; cloudy and squally with heavy rain.
<i>Minnyhive</i>	0° 45' S.	87° 10' E.	29° 97"	Noon, Calm 8 P.M., SE Midnight, SSE	Light. " "	Calms with rain; squalls light from SE at noon, all clouds coming from northward.
<i>Saint Marnock</i>	0° 58' N.	83° 3' E.	29° 88"	4 A.M., SSE 8 A.M., SSE Noon, SSE	2 to 3	Long heaving SE swell sometimes changing to south. Weather sultry, with heavy banks of clouds hanging at the horizon.
<i>Cuthona</i>	1° 36' N.	85° 4' E.	29° 92"	4 A.M., SSE 8 A.M., SSE Noon, SSE 4 P.M., SSE 8 P.M., West	Light. " " 2	Cloudy and overcast. Cloudy, with passing showers. Noon " " " 10 P.M. cloudy. 11 P.M. heavy and continuous rain. Light breeze.

THE FALSE POINT CYCLONE OF

NAMES OF SHIPS.	POSITION AT NOON.		Barometer reduced and corrected as nearly as possible for to A. S.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Blairgowrie</i> . . .	00° 6' S.	87° 51' E.	29.96"	4 A.M., S 8 A.M., S Noon, S 4 P.M., S 8 P.M., S Midnight, S	2-3 5-5 4-2 2-3 3-2 3-2	Wind light, heavy 7 to 8, sharp squall, 1 hour rain moderate, light, sultry, overcast, heavy, passing light clouds, distant lightning.
<i>Chanda</i> . . .	Coconada Roads.		29.88"	Noon, Westerly	Light.	(Midnight) light variable breeze, with dark heavy clouds.
<i>Governor Wilmot</i> .	Abreast Alguada, Light-House Diamond Island.		29.96"	4 A.M., variable airs 8 A.M., SEly. Noon, WSW 4 P.M., WSW 8 P.M., WSW Midnight, WSW	Very light. Very light. Moderate. 3	Ship left Diamond Island at noon bound for Calcutta. Sea smooth. Fine and clear. Sky very fine-looking.
<i>Erato</i> . . .	20° 01' N.	88° 52' E.	29.84"	S by W	...	2 A.M.—Weather cloudy and a greasy appearance in the SSE. Wind S by W; course steering NNW (True). Speed 6 knots; fresh breeze and a swell from the SW quarter. 7 A.M.—Bar. 29.93 and falling slowly. 8-30 A.M.—Increasing breeze from SW by S and heavy masses of black clouds flying across to the ENE. Furled top gallant sails, mainsail, and upper top sails. Noon.—Reefed foresail; whole gale at S.W. 5 P.M.—Weather moderated and wind veered greatly to the NW with a clear sky. Midnight. Hard squalls at NNW, and heavy rain.

These observations show that over almost the whole of the Bay, except close to the Sundarbans, the weather was fine, with only moderate winds. At the head of the Bay the *Kenyon*, which was just coming into Saugor Roads, met with fresh squalls from the south; the *Erato*, a little further to the south, reports a gale of wind followed by fine weather. These are probably the remains of the feeble depression which had passed inland from this area to the north of Calcutta during the previous night. Further south again, the *Brindisi* was almost off Vizagapatam, on her way from Madras to Calcutta, and had southerly swell with moderate breeze and fine weather. The other vessels report to a similar effect, excepting those that were to the south of the entrance of the Bay of Bengal, where some vessels experienced squally weather with rain. This, however, only indicates that the monsoon was blowing fairly strongly at the entrance of the Bay. The most important observations, recorded on this day, on vessels navigating the

Bay, are those of the *Governor Wilmot*, off Cape Negrais, in about latitude 16° north and longitude 94° east, and here the weather was fine and the sea smooth.

The pressures recorded in the logs of these vessels, agree very fairly with what might be expected from the land observations, and they appear to show that the description of the distribution of pressure above given is correct, and was about normal for September. The actual distribution, as deduced from both the land and sea observations, is shown in the first of the accompanying plates (Plate V).

The wind directions reported by vessels navigating the Bay, show that a steady south-westerly and southerly monsoon current, was blowing over the whole Bay.

Thus, then, so far as can be inferred, the weather over the whole of India and the Bay of Bengal on September 16th, 1885, was almost such as is normal for the time of the year.

17th September 1885.—The following table contains the land observations taken at 10 A.M. of this day:—

STATIONS.	Barometer reduced to 32° and sea level.	Change since previous day.	Wind direction.	Wind velocity, in miles per hour for previous 24 hours.	Normal velocity, September, miles per hour.	Temperature.	Cloud proportion.	Rainfall in inches.	WEATHER REMARKS.
Lahore . . .	29'768	—'085	SE	1	2'0	87'7	0	Nil	Fine weather.
Delhi . . .	29'795	—'032	N	4	3'9	88'2	0	Nil	Fair weather.
Lucknow . . .	29'775	—'034	NNE	2	2'7	91'1	0	Nil	Fine weather.
Ajmere . . .	29'832	+ '018	W	8	4'7	84'3	1	Nil	Do.
Allahabad . . .	29'774	—'037	SW	?	2'7	88'7	0	Nil	Do.
Patna . . .	29'796	—'043	E	2	3'0	87'6	6	Nil	Do.
Nagpur . . .	29'796	—'061	Calm	3	4'7	86'7	4	0'37	Do.
Bombay . . .	29'939	—'037	S	12	12'0	77'0	10	2'84	Sea rough.
Nancowry . . .	*29'887?	—'002	SW	5	9'6	77'5	8	Nil	Cloudy.
Port Blair . . .	29'926	—'061	WSW	7	10'3	82'7	8	0'50	Do.
Diamond Island . . .	29'908	—'066	W	7	6'8	83'9	4	Nil.	
Bassein . . .	29'935	—'012	SW	3	3'5	84'9	5	0'33	
Rangoon . . .	29'904	—'065	NW	4	4'2	83'3	5	2'28	
Theyetmyo . . .	29'873	—'066	SW	2	5'0	85'9	5	0'31	
Akyab . . .	29'891	—'048	SE	3	3	83'6	5	0'09	
Chittagong . . .	29'847	—'067	SSE	5	4'5	82'7	7	0'43	
Dacca . . .	29'798	—'059	ESE	7	4'6	80'9	10*	0'48	
Calcutta . . .	29'770	—'067	S	2	4'6	80'0	10	0'84	
Saugor Island . . .	29'784	—'055	WSW	12	9'4	79'4	8	2'83	Sea very smooth.
Midnapore . . .	29'792	—'050	S	2	...	82'5	8	0'15	
Balasore . . .	29'805	—'043	Calm	3	...	82'5	8	0'07	
Cuttack . . .	29'798	—'064	Calm	1	2'6	84'0	10	0'20	
False Point . . .	29'814	—'048	WSW	7	7'7	82'8	9	...	

* See note to table of observations for 16th September.

THE FALSE POINT CYCLONE OF

STATIONS.	Barometer reduced to 32°, and sea level.	Change since previous day.	Wind direction.	Wind velocity in miles per hour for previous 24 hours.	Normal velocity, September, miles per hour.	Temperature.	Cloud proportion.	Rainfall in inches.	WEATHER REMARKS.
Gopalpur . . .	29'809	—'051	SW	4	8'5	83'0	8	0'10	Sea rising.
Vizagapatam . .	29'813	—'068	SW	2	2'5	85'5	4	0'10	
Cocanada . . .	29'836	—'054	WSW	6	...	79'5	8	0'02	Sea very smooth.
Masulipatam . .	29'836	—'044	W	5	...	80'0	10	0'19	
Madras . . .	29'902	—'049	WNW	5	6'7	79'0	10	1'31	
Nagapatam . . .	29'924	—'046	W	2	5'5	85'5	7	0'08	
Trincomalee . .	*29'859†	—'001	SW	2	15'5	89'0†	10	...	
Galle . . .	29'978	—'024	W	9	8'5	82'5	6	0'12	Sea rising.
Colombo . . .	29'978	—'028	WSW	9	8'4	85'5	3	Nil.	Fine weather.

As will be seen in the table, the pressure had fallen over the whole of India by about 0'05 inch or 0'06 inch; and with but few exceptions, the fall had been pretty equal; thus, the meteorological conditions, shown by the land observations, had undergone only slight relative changes since the previous day. The small differences of pressure originally existing within the large area of nearly uniform pressure of the previous day, had perhaps slightly increased, but they were still small. Thus, from Lahore on the north to Masulipatam on the south, there was a difference of only 0'068 inch, and from Lahore to Dacca of only 0'03 inch; while, between Nagpur and Dacca any difference was negligible. On either side and to the south of this large area of nearly uniform pressure, there are the same bands of relatively high pressure; represented by the readings at Port Blair, 29'926 inches; at Rangoon, 29'904 inches; and at Bassein, 29'93 inches; and on the other side, at Bombay, 29'939 inches; at Madras, 29'902 inches; at Nagapatam, 29'924 inches; and at Galle, 29'978 inches.

Over the northern part of India, the winds continued rather irregular, and in most instances the velocities were small; while over the Bay, a steady westerly and south-westerly monsoon current was blowing. Generally speaking, the strength of the monsoon current, as judged by the wind velocities at coast stations, was about such as is usual in September; but at Port Blair, the registered wind was only 7 miles an hour, against a normal velocity of 10'3 miles; and at Nancowry, 5 miles was registered instead of 9'6 miles. This would seem to show that in the south-east of the Bay, there was an area of comparatively little air motion.

Though winds were of but moderate strength at all the land stations on this day, (the highest velocity being only 12 miles an hour, at Saugor Island), there had been a very distinct increase of movement since the previous day; and such was the case at the great majority of the coast stations. There was therefore a fair monsoon current blowing over the land, and the rainfall over Bengal continued to be about equal to the

* See note to table of observations for 16th September.

normal for the time of year. This is shown in the following table of the average rainfall of this day, in each Meteorological District :—

DISTRICT.	Number of Stations from which average is derived.	Average rainfall of District for September 17th, in inches.
Orissa	20	0'05
South-West Bengal	59	0'35
East Bengal	36	0'88
North Bengal	32	0'30
North Behar	24	0'18
South Behar	37	0'04
Chutia Nagpur	25	0'13

It will thus be seen that rain was practically withheld from South Behar and Orissa, while it was scanty in Chutia Nagpur and North Behar; but that the other districts received a fair amount of rain. The average fall for the whole province was equal to 0'28 inch, and was thus smaller than the normal for September (0'33 inch).

Heavier rain was falling at Rangoon (2'28 inches), and at Port Blair 0'50 inch was recorded. Further south, at Nancowry, no rain fell up to the morning of the 17th. At Bombay there was heavy rain on the 17th.

The meteorological information available for the sea area of the Bay of Bengal and to the south is contained in the table below :—

17th September 1885.

NAMES OF SHIPS.	POSITION AT NOON.		Barometer reduced and corrected as far as possible for 10 A.M.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
Goa	10° 00' N.	80° 33' E.	29'86"	4 A.M., W 8 A.M., SW Noon, SW 4 P.M., SW 8 P.M., SW Midnight, SW	4 4 4 4 4 2	Weather fine and clear. Sea smooth throughout. Current from noon of 16th. S 70° E; distant 12 miles.
Favonius	5° 47' N.	81° 23' E.	?	4 A.M., SSW 8 A.M., SSW Noon, SSW 4 P.M., SSW 8 P.M., SSW Midnight, SSW	4 4 4 6 6 3	Light passing showers. Smooth sea. Ends very fine.
Brindisi	20° 59' N.	88° 11' E.	29'77"	4 A.M., W by N 8 A.M.	Light. ...	Cloudy, overcast.

THE FALSE POINT CYCLONE OF

NAMES OF SHIPS.	POSITION AT NOON.		Barometer reduced and corrected as far as possible for 10 A.M.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Brindisi</i> —contd.				Noon	...	Rain.
		Off Saugor Island.		4 P.M.	...	
				8 P.M.	...	Fine weather.
				Midnight, calm	...	
<i>Britannia</i>	13° 02' N.	87° 8' E.	29° 86'	SW	4	Fine fresh cloudy weather.
<i>Barque Rollo</i>	6° 46' N.	87° 52' E.	29° 90'	Noon, SW	Light	Light and steady SW breezes. Cloudy throughout the day. Current S 27° E 19 miles.
<i>Governor Wilmot</i>	15° 29' N.	94° 00' E.	29° 93'	Noon, W	2	Noon very hot and sultry; suffocating hot.
				4 P.M. to 8 P.M., WNW	2	Sky glassy. Sea very smooth. Wind light and variable. Sent down felled royal masts, &c.
				Midnight	1	
<i>Barque Cynosure</i>	8° 09' N.	87° 40' E.	29° 89'	8 A.M., WSW	Moderate.	Moderate breeze and fine.
				Noon, WSW	Strong	Strong breeze and clear.
				8 P.M., WSW	Strong	Strong wind and weather.
<i>Calcutta</i>	4° 47' N.	88° 29' E.	?	Noon, SSW to WSW	...	Fine weather.
<i>Schooner Kunt Alfs-son.</i>	9° 49' N.	85° 02' E.	29° 90'	Noon, SW	Fresh	Fresh SW breeze. Small clouds. Fine weather; going 8 knots.
<i>Cuthona</i>	3° 12' N.	86° 10' E.	29° 93'	4 A.M., SSW	...	Heavy rain till 1-30 A.M.
				to	...	
				Noon, W	4	Fine and clear; moderate breeze, with occasional squalls and rain.
<i>Erato</i>	20° 17' N.	88° 28' E.	?	Noon, NNW	Strong	Strong NNW wind and frequent misty rain-squalls. A current setting WSW 1½ knots per hour allowed for. 10 P.M., wind NNE and squally, with light rain.
<i>Minnyhive</i>	0° 54' N.	87° 51' E.	29° 98'	Noon, variable	Light	Winds variable from SSE to WNW. Sky thickly overcast. 8 P.M. heavy rain. Brightening round moon.
<i>Saint Marnock</i>	1° 23' N.	83° 40' E.	29° 83'?	4 A.M., SSW	3	Southerly sea rolling up quickly.
				8 A.M., SW	3	
				Noon, WSW	4	Hot, sultry weather.
				4 P.M., SSE	4	Squally, with much rain.
				8 P.M., SE	5	Sharp squalls, with heavy rain.
				Midnight	5	
<i>Blairgowrie</i>	1° 33' N.	87° 23' E.	29° 96'	4 A.M., S 1 to 7 W	2-0	Light passing cloudy; 8 to noon squally with rain. SSE swell.
				8 A.M., N 7 to S 6 W	2-3	12 to 8 squally with rain; dull heavy, SSE and SW swell.
				Noon, S 6 W	3-5	
				4 P.M., S 6 W	5	
				8 P.M., S 6 W	5	
				Midnight, S 6 W.	5	

These observations show fairly well the character of the weather over the Bay. At the head of the Bay, near the Sandheads, it continued to be somewhat squally with a north-westerly wind, as shown by the log of the *Erato*; but the *Brindisi*, which was almost south of Saugor Island, reports a westerly wind with only cloudy weather and rain. In the middle of the Bay, the *Britannia* had fine fresh cloudy weather with south-westerly winds, of force 4; and all the vessels from the centre to the entrance of the Bay, report steady and moderate to fresh or strong south-westerly winds; nearer the equator, however, the weather was squally with heavy rain.

Again, on this day, the most important observations are furnished by the *Governor Wilmot*, which had left Diamond Island on the previous day, and, on the 17th, was about 60 miles to the south-west of that station. The report of the weather in this part of the Bay, is "very hot and sultry; suffocating hot; sky glassy, sea very smooth, wind light and variable, noon wind west, 4 P.M. to 8 P.M. west-north-west, and force 1 to 2."

It is clear, then, that in this portion of the Bay there was little or no horizontal air motion; and since both immediately to the south of this area and over the whole of the south of the Bay, a fairly strong monsoon was blowing, the only probable inference is that there must have been more or less ascensional air movement over this area. Why, over this part of the Bay, there should have been this absence of lateral air motion, and why this ascensional movement should have been set up, it is apparently impossible to explain.

The barometric observations of the ships agree with those of the land stations, and show that the pressure conditions resembled those of the previous day. Thus, there was a comparatively high pressure in the south-west, south and east of the Bay, and but slightly lower pressure over the whole of the northern and central portion. The differences were small, *viz.*, about a tenth of an inch between Saugor Island and the latitude of Ceylon. The distribution of pressure on this day is shown in Plate V.

18th of September 1885.—The following table gives some of the observations over the land area of India and at the stations on the coast of the Bay of Bengal for 10 A.M. of September 18th:—

STATIONS.	Barometer reduced to 32° and sea level.	Change since previous day.	Wind direction.	Wind velocity of previous 24 hours in miles per hour.	Normal velocity, September, miles per hour.	Temperature.	Cloud proportion.	Rainfall in inches.	WEATHER REMARKS.
Lahore . . .	29°8'18	+°050	S	3	2°0	87°2	0	<i>Nil</i>	Fine clear weather.
Delhi . . .	29°8'23	+°023	WNW	3	3°9	88°2	0	<i>Nil</i>	Ditto.
Lucknow . . .	29°8'06	+°031	N	3	2°7	90°1	3	<i>Nil</i>	Fine weather.
Ajmere . . .	29°8'06	—°026	W	8	4°7	83°3	5	0°01	Ditto.
Allahabad . . .	29°8'11	+°037	NW	?	2°7	88°2	0	<i>Nil</i>	Fine clear weather.
Patna . . .	29°8'21	+°025	NE	2	3°0	86°6	6	<i>Nil</i>	Ditto.
Nagpur . . .	29°8'17	+°021	Calm	4	4°7	88°7	2	<i>Nil</i>	Ditto.
Bombay . . .	29°9'38	—°001	E	8	12°0	82°5	6	0°17	Passing showers.
Nancowry . . .	29°9'59*	+°072?	SW	5	9°6	81°2	6	0°68	Partial clouds.
Port Blair . . .	29°9'22	—°004	WNW	8	10°3	75°7	9	4°73	Overcast. Drizzling. Raining all night.
* Diamond Island . . .	29°8'79	—°029	WNW	7	6°8	83°9	5	<i>Nil</i> .	

* See note to table for September 16th.

STATIONS.	Barometer reduced to 32° and sea level.	Change since previous day.	Wind direction.	Wind velocity of previous 24 hours in miles per hour.	Normal velocity, September, miles per hour.	Temperature.	Cloud proportion.	Rainfall in inches.	WEATHER REMARKS.
Bassein . . .	29'868	—'077	N	3	3'5	84'2	7	0'42	Partial clouds.
Rangoon . . .	29'890	—'014	NNE*	5	4'2	83'1	4	0'03	
Thayetmyo . . .	29'874	—'001	SSE	1	5'0	86'1	6	Nil.	
Akyab . . .	29'898	+ '007	NE	3	3'0	86'7	4	...	
Chittagong . . .	29'873	+ '026	SSE	5	4'5	82'7	8	0'07	
Burrisal . . .	29'770?	—'028	S	4	...	85'7	8	2'38	
Dacca . . .	29'831	+ '033	SSW	4	4'6	78'4	10	0'53	
Jessore . . .	29'827	+ '047	Calm	2	...	77'1	10	2'11	
Calcutta . . .	29'806	+ '036	SSW	3	4'6	84'0	9	0'12	
Saugor Island . . .	29'807	+ '023	SSW	9	9'4	86'4	6	...	
Midnapore . . .	29'805	+ '013	S	3	...	87'5	3	...	
Balasore . . .	29'818	+ '013	S	8	...	87'0	3	...	
Cuttack . . .	29'809	+ '011	SSW	2	2'6	87'1	5	...	Sea very smooth.
False Point . . .	29'819	+ '005	WSW	7	7'7	86'3	6	...	
Gopalpur . . .	29'810	+ '001	SE	4	8'5	86'6	5	...	Ditto.
Vizagapatam . . .	29'839	+ '026	W	2	2'5	83'5	10	7'30	
Cocanada . . .	29'839	+ '003	W	5	...	82'5	7	...	Ditto.
Masulipatam . . .	29'826	—'010	NW	7	?	86'0	9	...	
Madras . . .	29'885	—'017	W	6	6'7	87'0	2	...	
Negapatam . . .	29'926	+ '002	W	1	5'5	86'5	5	...	
Trincomalee . . .	*29'860?	+ '001	SW	2	15'5	88'0?	8	...	
Galle . . .	29'928	—'050	SSW	11	8'5	86'0	7	0'21	Sea rough.
Colombo . . .	30'001	+ '023	WSW	9	8'4	84'0	5	Nil.	

The meteorology of the land area of India on the 18th of September presents some features of considerable interest. Pressure still remained fairly uniform over the whole of Upper India, with the band of high pressure to the west and south-west of the Peninsula. But along the east coast of the Bay of Bengal, and probably in the middle of the Bay, near the east coast, some important changes were taking place.

At Nancowry, apparently, pressure had risen rather rapidly. This appearance may, indeed, be due to an erroneous reading on September 17, but if it represents a fact, Nancowry registered the highest pressure recorded at any station in the whole of the Indian area (29'959 inches); on the other hand, the pressure had fallen at Port Blair, Diamond Island, Rangoon and Bassein, though at Akyab and the stations to the north it was rising. At Madras and Masulipatam, it was falling also. This change appears to be a most important feature in the formation of the cyclone. There is a well defined area, represented by the above stations, where pressure was steadily decreasing; and this area of decreasing pressure was, to an equal extent, surrounded by areas of increasing pressure.

* See Note to Table for September 16th.

Over this area the winds were very variable. At Nancowry the direction was S.W., at Port Blair and also at Diamond Island WNW, at Rangoon NNE, at Bassein N, at Thayetmyo SSE, and at Akyab NE. Moreover, rain commenced to fall over this area of the Bay; Nancowry reported 0·68 inch and Port Blair the heavy fall of 4·73 inches. At Port Blair at 10 A.M., the weather was overcast and drizzling, and it had rained all the previous night. A local thunder-storm, accompanied by excessive rain (7·30 inches), was reported from Vizagapatam on this day, but this does not appear to have had any connection with the weather conditions in the east of the Bay.

To sum up the principal features of interest shown by the land observatories: there was an area of diminishing pressure in the eastern portion of the Bay, about midway down, surrounded by areas of increasing pressure. Where the pressure was low, the winds were variable and the rainfall heavy, being continuous in that part of the Bay represented by Port Blair.

The meteorology of the sea area of the Bay of Bengal is shown by the following observations, extracted from the logs of ships navigating the Bay on this day:—

18th September 1885.

NAMES OF SHIPS.	POSITION AT NOON.		Barometer reduced and corrected to 10 A. M. as near as possible.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
Goa	At Negapatam .		29°86"	4 A.M., SW by S	2	Fine weather with clear sky.
				8 A.M., SW by S	2	Sea smooth.
				Noon, S by W	2	Ditto.
				4 P.M., SSE	4	Ditto.
				8 P.M., S	4	Ditto.
•				Midnight, SSW	5	Wind freshening, heavy clouds rising and lightning from NW.
City of Agra . .	8° 5' N.	82° 57' E.	29°91"	4 A.M., SW	4	4 A.M. Moderate breeze and clear.
				8 A.M., SW	3	Cloudy sky. Smooth sea.
				Noon variable.	...	Noon. Light breeze and fine clear weather.
				8 P.M., Easterly	...	8 P.M. Light and clear, with a swell from SE.
				Midnight, Easterly		
Minnyhive . . .	3° 37' N.	88° 26' E.	29°92"	Noon, WSW	4	Light to fresh breeze, with hard squalls. Wind varying from SSW to WNW. Sky a dirty, wild-looking appearance, all scud coming from NNE.
Favonius	8° 08' N.	82° 35' E.	?	4 A.M., SSW	2	Very fine and moderate throughout.
				8 A.M., SSW	2	
				Noon, SSW.		
				4 P.M., SSW.		
				8 P.M., SSW	...	
•				Midnight.	...	Clear sky. Smooth sea.

THE FALSE POINT CYCLONE OF

NAMES OF SHIPS.	POSITION AT NOON.		Barometer reduced and corrected to 10 A.M. as near as possible.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Saint Marnock</i>	4° 26' N.	84° 19' E.	29°88"	4 A.M., SSW 8 A.M. Noon.	4 to 6	Squally, with rain. Southerly, confused sea. Overcast, with heavy rain.
				Midnight.	...	Fresh whole-sail breeze, and cloudy.
<i>Cuthona</i>	6° 14' N.	87° 27' E.	29°89"	8 A.M., SW to 4 P.M., WSW Midnight.	 4 ...	Fine moderate breeze. Squally. Lightning to northward.
<i>Blairgowrie</i>	5° 15' N.	87° 31' E.	29°92"	4 A.M., S 6 W 8 A.M., S 6 W Noon, S 6 W 4 P.M., S 6 W 8 P.M., S 6 W Midnight, S 6 W	5-6 5-6 5-6 5-6 5-6 5-6	Fresh monsoon; flying showers. SSW swell on; warm and heavy; lightning N and NE of N.
<i>Britannia</i>	15° 50' N.	87° 3' E.	29°86"	Noon, SW Midnight, WSW	5 5	Much lightning, with heavy showers.
<i>Barque Rollo</i>	9° 57' N.	88° 02' E.	29°80"	.....	...	Fresh and steady breezes WSW, and cloudy weather throughout.
<i>Governor Wilmot</i>	15° 37' N.	93° 20' E.	*29°78"	4 A.M., 1st part W 8 A.M., WSW Noon, W 4 P.M., WNW 8 P.M., NW Midnight, WNW	 2	Winds light and variable, very unsteady both in force and direction. Noon. Very hot, sultry and oppressive; what is it the sign of? Little head sea, westward; 4 to 8 variable airs and head sea; south sky clear, but a heavy bank of clouds in NE. Kind of misty ring round the moon, and head sea WNW.
<i>Barque Cynosure</i>	11° 28' N.	87° 58' E.	29°86"	8 A.M., WSW Noon, WSW 8 P.M., WSW	Strong	Strong breeze and clear weather. Ditto wind and weather. Ditto ditto.
<i>Calcutta</i>	8° 43' N.	88° 28' E.	29°92"	Noon, SW by W	...	Weather very hot.
<i>Schooner Kunt Alfsson</i>	12° 38' N.	85° 01' E.	29°90"	Noon, SW	Fresh.	Wind SW and WSW; later on, fine fresh breeze, not quite steady, 8½ to 6 knots.
<i>Erato</i>	At Sandheads.	?		Noon, SW by W	...	2 A.M. Wind backed to the SW by W, and at 5 A.M. weather cleared. Made all sail and stood to the NNW, and at noon took Pilot on board off E. C. L. V. 11 P.M. anchored in Saugor Roads.
<i>Chanda</i>	Gopalpur.		29°86"	Noon, SW	...	8 P.M. light breeze. Midnight, light breeze, clear.

* This is clearly a mistake for 29°88".

These observations give important information. In the north of the Bay, as shown by the logs of the *Erato* and of the *Chanda*, light south-westerly breezes were blowing, and the weather was fine. In the south, as shown by the logs of the *Kunt Alfsson*, *Cynosure*, *Barque Rollo*, *Calcutta*, *City of Agra*, *Favonius*, and *Goa*, moderate to strong south-westerly and west south-westerly breezes were blowing, and the weather is generally described as clear and hot. Still further south, at the entrance to the Bay, were the ships *Cuthona*, *Blairgowrie*, *St. Marnock*, and *Minnyhive*, and all report a strong monsoon with squally weather and generally much rain.

Only two vessels were navigating the central part of the Bay, but these give perhaps the most important observations of all. The *Britannia*, in Lat. $15^{\circ} 50'$ north and Long. $83^{\circ} 3'$ east, reports strong, south-westerly winds of force 5, much lightning and heavy showers. The *Governor Wilmot*, from Diamond Island, was in Lat. $15^{\circ} 37'$ north and Long. $93^{\circ} 20'$ east, and describes the weather on the 18th. as "winds light and variable, very unsteady both in force and direction. Noon, very hot, sultry and oppressive," and asks "what is it a sign of?" "Little head sea from (?) westward; 4 to 8 P.M. variable airs and head sea. 8 P.M. sky clear, but a heavy bank of clouds in north-east; kind of misty ring round the moon, and head sea west-north-west." Captain Clague, the master of this ship, in a second report, communicated to the Bengal Meteorological Office, writes that, on this day, wind commenced west to west-south-west, then went back to west; then it was variable; then west-north-west to north-west, and finally north-west by west.

The state of things, here described, presents a complete contrast to the conditions in all other parts of the Bay. To the north-west of the *Governor Wilmot's* position, a light south-west current was blowing, and to the west, south-west, and almost to the south of it, a very strong south-west monsoon; but over this part of the sea, and, as has been shown previously, on the neighbouring coasts, the winds were light and variable. Over the sea to the west and south of the *Governor Wilmot*, also there is evidence of heavy rainfall.

It is of course clear that the strong south-westerly current must have had some outlet, and the only possible explanation is that, over that part of the sea represented by the log of the *Governor Wilmot*, there must have been an upward air current, which drew off the strong winds blowing from the south. This will fully account for the rainfall at most of the land stations near this area, and for the heavy rain reported by the *Britannia*. It is however noticeable that, on this day, there is no appearance whatever of a cyclonic circulation of winds; and that over nearly the whole Bay, excepting only in the central part near the east coast, there was a strong south-westerly and westerly current. It was only between Akyab on the north and Port Blair on the south, and perhaps to the east of 88° or 90° east longitude, and on the adjacent land, that light variable winds prevailed.

It is to be regretted that the barometric observations on board ships are sometimes not so carefully and accurately recorded, and therefore so reliable as might be desired. On this day, the recorded reading of the barometer of the *Governor Wilmot*, when reduced and corrected according to the best available information, would seem to show that there had been a large and sudden fall of pressure near the position of this vessel. The reduced value of the reading, at 10 A.M. of the 18th September, is $29\cdot78$ inches, and this would indicate a fall of $0\cdot15$ inch since the previous day. But, as the ship was only about

60 miles west-south-west of Diamond Island, where the fall was only 0·029 inch, and as, by comparison with the reading of the ship itself on the 19th, that of the 18th would appear to have been at least a tenth of an inch too low, this latter cannot be accepted. The probable corrected reading will be about 29·88", and the fall since the previous day only 0·05 inch. This value will agree with the readings at the neighbouring land observatories. Even thus, it will be seen that the fall of pressure on the sea is slightly larger than that on the land.

Apparently, then, it may be accepted that, together with the upward movement current of the air, which must have existed over this part of the Bay, there was a fall of pressure at least equal to about a twentieth of an inch. Whether these two facts stand to each other in the relation of cause and effect, and what was the initial cause of these actions, it is of course impossible to determine.

Over the remainder of the Bay, the pressure reported by the ships agree well with the land observations; it is only in the case of the *Governor Wilmot* that any discrepancy appears. Accepting the observation of this ship, modified as above, the relative distribution of pressure over the Bay would appear to have changed but slightly since the previous day, and though the pressure was falling over the central eastern part of the Bay, it was still slightly higher over this area than in the north-west of the Bay. To the west-south-west of Diamond Island and north-west of the Andaman Islands, it was, however, distinctly lower than at Akyab. The distribution of barometric pressure on this day is shown in Plate V.

Briefly, the chief meteorological conditions of the area under discussion on the 18th of September were a decreasing pressure over the part of the Bay to the north-west of the Andamans, attended by ascensional air motion and rainfall, the rainfall being fed by a powerful south-west monsoon current blowing from the south and south-west of this area. Over the land area of northern India, light monsoon winds were blowing, attended with scanty rainfall.

19th of September 1885.—The following represent the principal land observations on this day in India, and at the coast stations round the Bay of Bengal at 10 A.M. of the 19th :—

STATIONS.	Barometer reduced to 32° and sea level.	Change since previous day.	Wind direction.	Wind velocity in miles per hour for previous 24 hours.	Normal velocity, September, miles per hour.	Temperature.	Cloud proportion.	Rainfall in inches.	WEATHER REMARKS.
Lahore . . .	29·809	—·009	N	2	2·0	85·7	8	Nil	Fine weather.
Delhi . . .	29·798	—·025	NW	5	3·9	86·2	2	Nil	Fine clear weather.
Lucknow . . .	29·779	—·027	NNE	4	2·7	93·0	0	Nil	Ditto.
Ajmere . . .	29·797	—·009	SW	8	4·7	84·3	6	...	Fine weather.
Allahabad . . .	29·780	—·031	W	?	2·7	89·7	0	Nil	Ditto.
Patna . . .	29·809	—·012	E	1	3·0	86·6	6	0·10	
Nagpur . . .	29·795	—·024	Calm	3	4·7	87·7	4	0·02	Ditto.
Bombay . . .	29·927	—·011	WNW	8	12·0	78·5	10	0·09	Overcast.
Nancowry . . .	29·959	0	SW	12	9·6	80·6	6	1·60	Partial clouds.

STATIONS.	Barometer reduced to 32° and sea level.	Change since previous day.	Wind direction.	Wind velocity in miles per hour for previous 24 hours.	Normal velocity, September, miles per hour.	Temperature.	Cloud proportion.	Rainfall in inches.	WEATHER REMARKS.
Port Blair . . .	29'846	—'076	SW	8	10'3	77'6	10	3'76	Raining from 9 to 15½ hours of 18th, and all night overcast, drizzling.
Diamond Island . .	29'809	—'069	ENE	10	6'8	81'9	7	0'37	Strong wind. Thunder and Lightning at distance.
Bassein . . .	29'820	—'048	E	4	3'5	81'5	10	1'45	Partial clouds.
Rangoon . . .	29'858	—'032	ENE	4	4'2	80'6	10	0'85	Passing showers.
Thayetmyo . . .	29'849	—'035	SE	1	5'0	86'1	4	Nil	Fine weather.
Akyab . . .	29'855	—'043	ENE	2	3'0	84'6	3	...	
Chittagong . . .	29'843	—'030	Calm	3	4'5	84'7	5	...	
Burrisal . . .	29'813	+ '043 ²	S	4	...	84'7	3	0'90	
Dacca . . .	29'819	—'012	SSE	3	4'6	83'9	8	0'33	
Jessore . . .	29'805	—'022	S	3	...	83'9	10	0'06	
Calcutta . . .	29'795	—'011	SSW	3	4'6	84'5	8	...	
Saugor Island . .	29'790	—'017	S	10	9'4	86'4	4	...	Sea very smooth.
Midnapore . . .	29'795	—'010	S	2	...	86'5	6	...	
Balasure . . .	29'772	—'046	ESE	5	...	88'0	3	...	
Cuttack . . .	29'779	—'030	Calm	1	2'6	85'5	5	0'06	
False Point . . .	29'795	—'024	WSW	6	7'7	86'8	8	...	
Gopalpur . . .	29'782	—'028	Calm	3	8'5	89'6	4	...	Ditto.
Vizagapatam . .	29'791	—'048	W	2	2'5	85'5	3	...	
Cocanada . . .	29'795	—'044	W	4	...	82'5	10	0'19	Ditto.
Masulipatam . .	29'784	—'042	NW	6	?	85'0	8	...	
Madras . . .	29'847	—'038	W	6	6'7	86'5	5	1'67	
Negapatam . . .	29'858	—'068	W	3	5'5	87'0	4	...	
Trincomalee . .	29'865	+ '005	SW	?	15'5	89'0	6	...	
Galle . . .	29'937	+ '009	NW	11	8'5	83'5	5	0'19	Sea rising.
Colombo . . .	29'953	—'048	SW	10	8'4	82'0	3	0'03	

The observations over the land area of Upper India, on September 19th, show that there had been no important change. Fine weather with light and somewhat variable winds, and a slowly oscillating barometer were the general conditions. This remark applies to the whole of the stations in the above table, excepting those in the south and east of the Bay of Bengal. At these stations, certain changes are seen to have occurred since the previous day, which indicate the incipient formation of the cyclone. In the south of the Bay, at Nancowry, the wind velocity which had been

previously below the normal for the season, had increased; for, on the morning of the 18th, the south-westerly wind had averaged only 5 miles an hour, while, on the 19th, its velocity was 12 miles; also in Ceylon at Colombo, the south-west wind had increased from 9 to 10 miles an hour, the normal velocity for September being 8·4 miles. These observations show that there was a continued and increasing inrush of south-westerly winds in the south of the Bay. The observations on the Arakan coast still show light north-easterly winds, and similar conditions were reported from Rangoon and Bassein; while, at Diamond Island, an east-north-east wind had averaged 10 miles an hour for the previous 24 hours, as against 7 miles an hour on the 8th.* The wind velocity at this station, at 10 A.M. on the 19th, was 22 miles. Thus, a strong north-easterly current was blowing from Pegu and Arakan towards the sea area, while a powerful south-westerly wind was blowing from the south of the Bay towards the same area. Continuous rain was also reported from the Andaman Islands, and no less than 3·76 inches of rain had fallen up to 10 A.M. of the 19th. On the 18th, 4·73 inches had been reported, and thus 8·49 inches had fallen in the two days. While the pressure was fairly steady over the whole of northern India it continued falling somewhat rapidly in the eastern part of the central region of the Bay; at Diamond Island the fall amounted to 0·064 "and at Port Blair to 0·096."

The conditions shown by the land observations of the 19th of September are, then, a strong and strengthening south-westerly current blowing from the entrance of the Bay, and a strong and increasing current blowing from the north-east towards an area of steadily falling pressure, over which area extremely heavy rain was falling; this was situated to the south-west of Diamond Island.

In Bengal, light to moderate rain continued on the 19th. In South Behar and Chutia Nagpur, rain was decidedly more frequent and plentiful than it had been on several days previously, but in Orissa and North Behar the amount was very small. The average rainfall on September 19th in each of the meteorological districts of Bengal is shown in the following table:—

DISTRICT.	Number of reporting stations from which average is derived.	Average rainfall of District for September 19th, in inches.
Orissa	20	0·10
South-West Bengal	59	0·27
East Bengal	36	0·24
North Bengal	33	0·49
North Behar	24	0·09
South Behar	37	0·30
Chutia Nagpur	25	0·35

This gives a general average of 0·24 inch over the whole Province for this day, while the normal daily fall for September is 0·33 inch.

The meteorology of the sea area on the 19th is shown in the logs of the vessels navigating the Bay of Bengal, which are given in the following table:—

19th September 1885.

NAMES OF SHIPS.	POSITION AT NOON.		Barometer reduced and corrected as nearly as possible for 10 A.M.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
S. S. City of Agra .	12° 9' N.	84° 22' E.	29° 81"	4 A.M., Southerly 8 A.M., to Noon, WSW 4 P.M., WSW. 8 P.M., WSW Midnight, WSW.	3 ... 4	4 A.M. Light breeze and cloudy weather. Sea moderate. Noon. Moderate and clear. 8 P.M. Moderate and cloudy weather.
Minnihive .	6° 38' N.	89° 12' E.	29° 88"	Noon, W	6	Every indication of bad weather to northward. Dense clouds rising from N W to N E, with bad lightning.
Saint Marnock .	7° 29' N.	85° 32' E.	29° 88"	4 A.M., SW. 8 A.M., SW. Noon, SW 4 P.M., S W. 8 P.M., S W. Midnight, WSW.	4—6	Fresh to strong breeze. Sea confused; shipping much water on deck.
Cuthona .	9° 59' N.	87° 57' E.	29° 78"	4 A.M., WSW 8 A.M. Noon. 4 P.M. 8 P.M. Midnight, W by S	Moderate. 4	Puffy, smooth water. Moderate breeze. Frequent flashes of lightning to northward, and an apparent bank there. Sunset. Sky red-looking. Frequent lightning to NE & W.
Blairgowrie .	9° 18' N.	87° 26' E.	29° 85"	4 A.M., S by W 8 A.M., S by W Noon, S 6 to 4 W 4 P.M., S 4 W 8 P.M., S 4-3 W	6 6 6 6 6	Fresh monsoon; dull, heavy, looks like a change. Lightning N & NE.
Favonius .	10° 46' N.	83° 37' E.	29° 74"	4 A.M., SW. 8 A.M., SW Noon, SW. 4 P.M., SW. 8 P.M., SW. Midnight, SW	... ... ... ... ...	Fine weather and clear sky. Smooth sea.

THE FALSE POINT CYCLONE OF

NAMES OF SHIPS.	POSITION AT NOON.		Barometer reduced and corrected as nearly as possible for 10 A. M.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Britannia</i> . . .	18° 20' N.	87° 44' E.	29° 86"	Noon, SW	4	Hot and sultry weather throughout.
<i>S. S. Chanda</i> . . .	20° 50' N.	87° 51' E.	29° 77"	Noon, NW & Southerly.	Light	8 A.M. Light breeze. Cloudy. 4 P.M. Light breeze, fine. Midnight. Light breeze; at anchor Saugor.
<i>S. S. Clan MacIntosh.</i>	13° 14' N.	80° 29' E.	?	Noon, Calm.	...	Calm and overcast. 8 P.M. Showers, similar weather. Midnight. Light winds and cloudy.
<i>Schooner Kunt Alfsson.</i>	14° 56' N.	85° 10' E.	?	Noon, WSW	Fresh	Wind SW & WSW, fresh breeze, but wind a little lighter than on previous day.
<i>Barque Rollo</i> . . .	12° 35' N.	88° 0' E.	29° 80"	Noon, W by S	Fresh	Fresh breezes from W by S to W by N and overcast.
<i>Governor Wilmot</i> . . .	14° 27' N.	92° 8' E.	29° 79"	4 A.M., NW	6	Midnight. Rain; very overcast and squally-looking, with smooth water; 12 to 4 increasing breeze, with rain. 4 A.M. Constant rain and big sea. 8 A.M. very squally. Strong breeze. Constant rain.
				8 A.M., to	6	
				Noon, NW by W	...	
				4 P.M., Variable	7	
				8 P.M., W	8	
<i>Barque Cynosure</i> . . .	14° 23' N.	88° 09' E.	29° 81"	Midnight, WNW	...	Forenoon. Dirty rainy weather. Noon. Constant heavy rain. Wind very unsteady. Rain all times. 4 P.M. Very heavy rain and increasing breeze. Wind W. 8 P.M. Whole gale.
				8 A.M., W	Moderate.	
				Noon W	...	
<i>Calcutta</i> . . .	12° 9' N.	88° 42' E.	29° 82"	8 P.M., WNW	Light	Moderate breeze and fine weather. Moderate breeze, wind and weather. Light breeze and cloudy; very sultry.
				Noon, SW by W to WSW	...	
<i>S. S. Goa</i> . . .	Moored at Madras.	?	?	4 A.M., SSW	5	Weather very hot. Occasional showers. Fine weather and cloudy, and continual lightning.
				8 A.M., NW	4	
				Noon, NW	4	
				4 P.M., NW	4	
				8 P.M., NW	4	
				Midnight, NW	4	Sea smooth.

Two ships only were in the north of the Bay, the *Chanda* and the *Britannia*, and these report fine weather with light and variable winds; the *Britannia* also adds that it was hot and sultry. The *Kunt Alfsson* and *Cynosure* were almost in the middle of the Bay; and these also report fine weather, with fresh westerly and west-south-westerly breezes. The *Goa* and *Clan MacIntosh* were off Madras, and also report generally fine weather. Further south, from about the latitude of Port Blair down to that of Galle, there were no less than eight vessels. All of these report south-westerly and westerly winds of moderate force, and in no case was the force greater than would be called a strong breeze. Ships

in the south-east of the Bay, *viz.*, the *Cuthona*, *Blairgowrie* and *Minnihive*, seem to have experienced stronger winds than those to the westward, and report the appearance of unsettled weather to northward. For example, "frequent flashes of lightning to the north; an apparent bank there," "looks like change; lightning to north and north-east, every indication of bad weather to the north, dense clouds rising from north-west to north-east, with bad lightning," &c.

The barometric observations of these ships also indicate that the pressure to the west or the north-west of the Andamans was comparatively low, and thus confirm the indications of the land observations on this day.

The most important observations however still remain to be considered separately. They are those taken on board the *Governor Wilmot*, from which it is evident that while, up to the morning of the 19th, no cyclone had been formed, during this day the cyclone was rapidly forming near the position of the ship; and that, by the evening, the cyclone had been generated between the position of the ship and the Diamond Island observatory. The observations made on this ship are therefore worthy of detailed study.

The log shows that, at midday of the 19th, she was in latitude $14^{\circ} 27' N.$ and longitude $92^{\circ} 8' E.$, or about 170 miles south-west of Diamond Island, and 80 miles to the north-west of the Andaman Islands. Thus, the vessel had only moved a few miles in a south-westerly direction during the previous 24 hours. On the previous evening, the log indicated the existence of a heavy bank of clouds to the north-east of the vessel, accompanied with very vivid lightning. At midnight of the 18th Captain Clague remarks "rain, but very overcast and squally looking, with smooth water; midnight to 4 A.M.—increasing breeze with rain; 4 A.M.—constant rain and big sea; 8 A.M.—very squally, strong breeze, constant rain; forenoon—dirty rainy weather; noon—constant heavy rain, wind very unsteady, rain all times; 4 P.M.—very heavy rain and increasing breeze; 8 P.M.—whole gale." The changes of wind are—4 A.M., north-west changing to north-west by west, with force 6; at noon, there was a period of variable winds, and then the wind went round to west and west-north-west, with force 8, in the course of the evening. At Diamond Island, which was only 170 miles to the north-east of the position of the ship, the wind at 10 A.M. was east-north-east, and the average wind velocity up to that time, from 4 P.M. on the previous day, had been 10 miles an hour only. At 10 A.M., however, the wind had increased and the observation shows 22 miles an hour; from 10 A.M. to 4 P.M., the velocity became 24 miles an hour; and at 4 P.M., the direction was east. From that hour up till the next morning, the velocity averaged 26 miles an hour. These observations seem to show that, up to 10 A.M. of the 19th, no actual cyclone existed, but that from that time it formed rapidly. The wind directions of the *Governor Wilmot* and those of Diamond Island, taken together, show that the cyclone must have originated between the two places; and from the observations of the *Governor Wilmot* at noon, it would seem that that vessel was then nearly at the centre of the place where the cyclone was forming. By the evening, the cyclone lay to north-north-east or north-east of the position of the ship; being, at first, a small storm and of little force. The formation of the cyclone therefore dates from the afternoon of the 19th, and the site of its origin was between $14^{\circ} 30' N.$ and $15^{\circ} N.$ and between $92^{\circ} 30'$ and $93^{\circ} E.$

The distribution of pressures and the wind directions over the whole area treated of are shown in Plate V.

20th of September.—The following table contains the observations taken at inland stations, and at coast stations round the Bay of Bengal, at 10 A.M. on the 20th of September :—

STATIONS.	Barometer reduced to 32° and sea-level.	Change since previous day.	Wind direction.	Wind velocity in miles per hour for previous 24 hours.	Normal velocity, September, miles per hour.	Temperature.	Cloud proportion.	Rainfall in inches.	WEATHER REMARKS.
Lahore . . .	29'867	+ '058	SE	6	2'0	71'6	10	<i>Nil</i>	Dark gloomy weather.
Delhi . . .	29'797	— '001	NW	2	3'9	83'2	8	0'06	
Lucknow . . .	29'748	+ '005	W	3	2'7	90'1	4	<i>Nil</i>	Fine weather.
Ajmere . . .	29'717	?	S	8	4'7	83'3	3	<i>Nil</i>	Ditto.
Allahabad . . .	29'769	— '011	NW	7	2'7	87'7	2	<i>Nil</i>	Ditto.
Patna . . .	29'801	— '008	SE	2	3'0	84'6	8	<i>Nil</i>	Ditto.
Nagpur . . .	29'757	— '036	Calm.	6	4'7	85'7	4	0'14	Ditto.
Bombay . . .	29'880	— '047	ESE	10	12'0	82'0	7	0'09	Ditto.
Nancowry . . .	29'922	— '037	SSW	12	9'6	84'0	6	0'27	Blue sky.
Port Blair . . .	29'813	— '033	WSW	15	10'3	74'7	10	1'96	Overcast, drizzling rain.
Diamond Island . . .	29'757	— '052	SE	25	6'8	79'4	8	0'32	Sea very rough.
Bassein . . .	29'776	— '044	ESE	8	3'5	81'7	8	0'57	Partial clouds.
Rangoon . . .	29'830	— '028	ESE	6	4'2	82'1	9	0'15	Fine weather.
Thayetmyo . . .	29'843	— '007	S	1	5'0	82'3	10	0'30	Dark gloomy weather.
Akyab . . .	29'805	— '050	NE	2	3'0	85'2	2	...	
Chittagong . . .	29'797	— '046	Calm	1	4'5	85'2	3	...	
Burrisal . . .	29'791	— '022	S	3	...	85'7	3	...	
Dacca . . .	29'807	— '012	SSE	2	4'6	85'9	5	...	
Jessore . . .	29'799	— '006	SSE	3	...	86'4	5	...	
Calcutta . . .	29'789	— '006	ESE	4	4'6	84'5	6	0'04	
Saugor Island . . .	29'786	— '004	SSE	4	9'4	85'4	6	...	
Midnapore . . .	29'798	+ '003	NE	3	...	81'5	8	0'01	
Balasore . . .	29'773	+ '001	SE	4	...	87'5	6	1'38	
Cuttack . . .	29'766	— '013	Calm	1	2'6	86'6	8	...	
False Point . . .	29'783	— '012	SSE	7	7'7	86'3	7	...	
Gopalpur . . .	29'759	— '023	SE	2	8'5	86'6	7	...	Sea very smooth.
Vizagapatam . . .	29'749	— '042	SE	3	2'5	85'5	4	0'10	
Cocanada . . .	29'742	— '053	E	3	?	83'6	4	...	Sea very smooth.
Masulipatam . . .	29'746	— '038	NW	5	?	84'5	10	...	
Madras . . .	29'791	— '056	WNW	6	6'7	87'0	3	...	
Negapatam . . .	29'832	— '026	W	2	5'5	85'5	6	...	
Trincomalee . . .	29'873	+ '008	SW	7	15'5	86'0	10	...	
Galle . . .	29'906	— '031	WNW	13	8'5	81'5	6	0'46	
Colombo . . .	29'900	— '053	WSW	9	8'4	85'5	4	<i>Nil</i>	Fine weather.

Again, on this day, the changes over the land area of Upper India were of little or no importance, and show no practical change from the conditions of the previous few days. There was the continued slow oscillation of the barometer, accompanied with light winds of rather variable direction. Light rain had fallen at Delhi, at Nagpur and Bombay; but generally Upper India was rainless. In this region, therefore, the weather showed no abnormal conditions.

At the coast stations round the Bay certain changes were setting in, in connection with the formation of the cyclone off the Andaman Islands on the previous day, and its gradual development; but they were for the most part small. Almost all stations reported a slowly falling barometer, the fall being greatest at Madras (0'056 inch), and at Diamond Island, where however it was 0'052 inches. The winds had become more or less easterly, at all the coast stations from Diamond Island round to Cocanada; while from Masulipatam southwards, they were more or less westerly. Over the greater part of the land area, the winds continued light, but in the east and south-east of the Bay, a great change had taken place; and, as already mentioned, the velocity at Diamond Island had become very considerable; for the 24 hours, preceding 10 A.M. of this day, it had averaged 25 miles an hour, and the observation which was taken at 10 A.M. showed a velocity of 28 miles an hour. At Port Blair, also, it had increased, and had averaged 15 miles an hour for the previous 24 hours; while, at Nancowry, it was 12 miles an hour. Moderate to heavy rain also continued in the south-east of the Bay, as is shown by Port Blair, which recorded 1'96 inches of rain.

The conditions, shown by the observations round the coast on the morning of the 20th, were a continued fall of pressure across the middle of the Bay, a strong easterly tendency in the winds in the north, a rapid strengthening of those in the east and south-east, and continued rainfall over the same area.

In Bengal, the rain continued light and local over the greater part of the Province, and the districts of Orissa, South-Western, Eastern and Northern Bengal were practically rainless; though, in Behar and Chutia Nagpur, light or moderate rain continued. This is shown in the following tabular statement, which gives the average rainfall in each district of the Province on this day.

DISTRICT.	Number of Stations from which average is derived.	Average rainfall of District on September 20th in inches.
Orissa	18	0'08
South-West Bengal	59	0'11
East Bengal	36	0'01
North Bengal	33	0'08
North Behar	24	0'27
South Behar	37	0'25
Chutia Nagpur	25	0'22

This gives a general average of 0'13 inch over the whole of Bengal, which is only about one-third of the normal daily amount.

The meteorology of the Bay of Bengal, on the 20th, is represented by a considerable number of ships. The principal observations, thus obtained, are contained in the following table, and the distribution of pressure and the wind directions over the Bay of Bengal and over Bengal are shown in Plate VI:—

20th September 1885.

NAME OF SHIP.	POSITION AT NOON.		Barometer reduced and corrected as far as possible to 32 A.M.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
S. S. <i>City of Agra</i>	16° 5' N.	86° 4' E.	29° 76"	4 A.M., Westerly 8 A.M. to Noon, North. 8 P.M., NE Midnight, NE	3 ... 2 3 ...	4 A.M. Light and clear passing clouds. Southerly swell. Noon. Cloudy and rainy-looking weather. Light breeze and overcast sky.
<i>Minnyhive</i>	10° 05' N.	89° 36' E.	29° 79"	Noon, WSW 4 P.M., W by S 8 P.M., W by S Midnight, W by N	6	Weather very unsettled. Heavy swell from SW. Reduced sail, finding we are getting into bad-weather.
<i>Calcutta</i>	14° 57' N.	88° 57' E.	29° 78"	Noon, W to NW	...	Position by account; no observations. Sky overcast and hazy. Several flashes of lightning in the SW after sunset. Took in all light sails. About midnight lightning also in NE.
<i>Saint Marnock</i>	10° 32' N.	86° 39' E.	29° 87"	4 A.M., SW 8 P.M., SW	5 to 6 ...	Fresh breeze, and cloudy south west; high confused sea. Shipping much water on deck.
S. S. <i>Cannara</i>	17° 59' N.	91° 12' E.	29° 75"	4 A.M., ENE 8 A.M., ENE Noon, ENE 8 P.M., N Midnight, N	5	Fresh breeze and cloudy. Squally, moderate sea. Fine clear weather. Moderate breeze and passing clouds. Smooth sea.
<i>Cuthona</i>	13° 5' N.	87° 51' E.	29° 71"	4 A.M., W by S 8 A.M. 8 P.M., WNW	... 10 11 insqualls	Smooth sea. Thick and black-looking; with frequent lightning. Heavy squalls and gusts. Very heavy squalls with thunder and lightning. Hove-to under three lower-top-sails on port tack. Very heavy and continuous rain.

NAME OF SHIP.	POSITION AT NOON.		Barometer reduced and corrected as far as possible to 10 A. M.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Blairgowrie</i>	12° 38' N.	88° 6' E.	29° 74"	4 A.M., S to W 8 A.M., S to W Noon, S to W 4 P.M., S to W. 8 P.M., S to W Midnight, S to W	5-7 6-7 6-7 6-7 6-7 6-7	Fresh monsoon. Gusty; ugly looking to the north of us. Sharp thunderstorm passed north of us. Vivid lightning N and NE of us.
<i>Britannia</i>	19° 36' N.	87° 36' E.	29° 81"	Noon, SW to SE	3	Wind variable all day, and light with sultry weather. Lightning in the SE, and thunder at night.
Schooner <i>Kunt Alfonso</i> .	16° 14' N.	85° 12' E.	?	2 P.M., WSW	Very light; variable.	WSW winds taken off, nearly calm; cloudy and squally; thick round the horizon; raining from noon to 2 P.M. Calm, very light easterly breeze, with squall and rain later on ESE. Small breeze, light clouds. Barometer little lower, and continuing to go down.
S. S. <i>Quangtung</i>	10 P.M. 21° 01' N.	88° 13' E.	?	Midnight, SE by E	2	9° 50 set course 5° 38' E (true); dipped Eastern Channel Light V., 32° E. (true); midnight, sea smooth.
S. S. <i>Clan MacIntosh</i>	16° 31' N.	83° 50' E.	29° 76"	4 A.M. 8 A.M. Noon 4 P.M. 8 P.M. Midnight	4 2 4 4 4 4	1 A.M. Light variable winds and overcast; squally at times with thunder and heavy rain. 4 A.M. Showery with passing squall from NNE. Noon, light variable airs and sky cloudy. 1 P.M. Light winds and clear weather. 8 P.M. Light winds with passing clouds. Midnight, light winds with passing clouds.
Barque <i>Rollo</i>	14° 43' N.	87° 43' E.	29° 60"	W by N	Fresh	First part fresh W by N breezes, latter baffling from westward.
Governor <i>Wilnot</i>	14° 45' N.	92° 20' E.	29° 50"	4 A.M., WNW 8 A.M., W Noon, W 4 P.M., SW 8 P.M., S Midnight, S	10 11 11 11 9 7	Hauled upper top-sails. Whole gale; furled foresail, and fore and main topsails; goose-winged lower main topsail; blowing very hard. 8 A.M. regular hurricane; sky black; thick clouds, low; sea rough, breaking on board; constant heavy rain. Barometer very low. Sky thick and black. At noon more like night. 6 P.M. weather broke.
Barque <i>Cynosure</i>	8 A.M. 15° 35' N.	88° 22' E.	29° 66"	8 A.M., WNW Noon, WNW 8 P.M., WNW	Moderate. Light	Moderate breeze and cloudy. Light airs and calm; thunder and lightning, with squalls and heavy rain. Latter part heavy weather.

These observations show, very clearly, the weather conditions of the Bay. At the head of the Bay, the *Coleroon* pilot vessel, which was at the Sandheads, and the *Booldana*, which was off False Point, report very fine clear weather, with light southerly winds. The *Britannia*, which was about 80 miles to the south-east of False Point, had light variable winds, from between south-east and south-west, with very sultry weather, and there was lightning to the south-east, all night, with thunder. This was of course the direction of the storm. The *Clan MacIntosh* and the *Kunt Alfsson* were in the western part of the Bay, some 200 miles to the east of Masulipatam, and they report light variable westerly winds, nearly calm; and that afterwards it was cloudy and squally with rain. The *Kunt Alfsson* also records that the barometer was lower and falling. The *City of Agra* was a little to the south-east of the *Kunt Alfsson*, and reported a barometer reading of 29.76 inches, and a northerly breeze, cloudy and rainy weather with southerly swell. In the south of the Bay, to the west and south-west of the Andamans, there were no less than 6 vessels. The *Minnyhive* was considerably south of the Andamans, and had west and south-westerly wind of force 6 with very unsettled weather, and heavy swell from the south-west. The *Blairgowrie* and *Cuthona*, which were about 300 miles to the west of the Andamans, had south-westerly and west-south-westerly winds, very heavy continuous rain, very heavy squalls, ugly-looking weather to the north, sharp thunderstorms to the north, vivid lightning to the north and north-east. About 300 to 350 miles in a west-north-westerly direction from the Andaman Islands, were the Barque *Rollo*, the *Calcutta*, and the *Cynosure*. The Barque *Rollo* and the *Calcutta* report a fresh west-north-westerly breeze, and the *Calcutta* notes lightning to the south-west and north-east. Further, the *Cynosure* experienced first, light airs and calms, and afterwards thunder and lightning, with squalls and heavy rain. In the latter part of the day it was therefore entering on the storm area. The *Cynosure* registered a barometric pressure of 29.66 inches, but either the position of the vessel as given must have been wrong, or the barometer was read rather too low.

On the north of the storm area was the S.S. *Canara*, which had left Rangoon early in the morning of the previous day, on her way to Calcutta. On the 19th she must have passed to the north of the area over which the storm was forming, and beyond experiencing a fresh breeze from east by north, as she passed Diamond Island, and subsequently an east-north-easterly breeze of force 4, no mention is made of any unusual weather. At 8 A.M. on the morning of the 20th, she experienced an east-north-easterly breeze of force 5, with squally weather and moderate sea; and as she proceeded on her course, the wind became north, at 8 P.M. its force moderated, and sea became smooth. It is evident that, during the whole of this day, the *Canara* was passing well to the north of the storm; and probably, so far as can be judged by the condition of the weather and the reading of the barometer, it was nearest to the cyclone at about 8 A.M. of the 20th, when the storm must have been to the south or south-south-west of the position of the steamer.

As on the previous days, the most valuable and interesting log is that contributed by Captain Clague of the *Governor Wilmot*. This ship had apparently scarcely changed its position since the previous day, and it was still about 80 miles north-west of the Andaman Islands, and about 170 miles south-west of Diamond Island. In addition to the log extracted in the above table, Captain Clague has communicated his own notes on the weather, from which the following description is taken—midnight of 19th "strong gales,

constant rain, and hard squalls, wind west to west by south, barometer slightly falling 4 A.M., barometer falling, hard squalls from the west to west-south-west, black and dirty-looking; 8 A.M., a regular hurricane, wind howling again, sea very high, but rain, nothing but rain, all the time, one constant heavy squall. Could not see fore end of ship, that black and dirty, sky appearance very low, wind a-howling. Noon just same weather, raining and blowing a perfect hurricane, wind west-south-west; 6 P.M., weather broke, barometer going up." The barometric readings were taken from midnight of the 19th, every 4 hours, and the lowest reading (29.48 inches) was recorded at 8 A.M., when the wind was west. By noon, the pressure had risen two-hundredths of an inch, and wind had become west-south-westerly, and in the evening it had risen a tenth of an inch, and weather had "broken," and was improving. It would therefore appear that the centre of the cyclone was to the north, or perhaps north north-west, of the *Governor Wilmot* on the morning of this day, and that the centre was nearest to it at about 8 A.M. The cyclone appears to have been then moving comparatively slowly, and the probable position of the centre, at 10 A.M. of this day, was about $15^{\circ} 30'$ N. by $91^{\circ} 30'$ E. This would then be about 60 miles, in a north-north-westerly direction from the *Governor Wilmot*.

This appears to be the most probable position of the centre of the storm, when all the available observations of wind direction and barometer are taken into consideration, but the wind observations on board the *Governor Wilmot* taken alone, would perhaps place the storm a little more to the east. But it must be observed that the position of the *Governor Wilmot* at noon on this day was obtained only by dead reckoning, and it is more than probable that the position of the ship was more to the west, than is laid down in the chart for that day. There is also the third consideration, that in iron ships, there is a very considerable "heeling error of the compass," and under the influence of strong beam winds, it is stated the north point of the compass will be drawn to windward, which might account for a wind being reported at west, when in reality it may have been west-south-west.

So far as the observations of the 20th show then, the above was the position of the centre of the storm on this day; and it had, from this morning, commenced its forward movement. Comparing the position which the storm probably occupied on the afternoon of the previous day, with that determined for the 20th, it would appear to have moved about 80 miles in a north-westerly direction in the interval. It will also be noticed that though the *Governor Wilmot* was only at a short distance from the centre, the lowest recorded pressure was only 29.47. As will be seen, this is in marked contrast with the pressures subsequently recorded.

September 21st.—The following table gives the observations in Upper India and at the coast stations round the Bay of Bengal at 10 A.M. of this date :—

STATIONS.	Barometer reduced to 32° and sea level.	Change since previous day.	Wind direction.	Wind Velocity in miles per hour for previous 24 hours.	Normal velocity, September, miles per hour.	Tempera- ture.	Cloud proportion.	Rainfall in inches.	WEATHER REMARKS.
Lahore . . .	29·875	+·008	W	1	2·0	82·7	0	Nil	Fine clear weather.
Delhi . . .	29·848	+·051	NE	2	3·9	85·2	2	Nil	Ditto.
Lucknow . . .	29·824	+·040	NW	4	2·7	84·2	9	0·07	Fine weather.
Ajmere . . .	29·875	?	NE	8	4·7	81·3	1	0·20	Ditto.
Allahabad . . .	29·793	+·024	NE	?	2·7	84·7	8	0·53	Thunderstorm.
Patna . . .	29·813	+·012	E	2	3·0	86·6	6	0·01	
Nagpur . . .	29·756	—·001	ENE	3	4·7	84·7	5	1·29	
Bombay . . .	29·895	+·015	NNE	9	12·0	83·0	2	Nil.	
Nancowry . . .	29·911	—·001	SSW	5	9·6	84·2	5	0·51	Blue sky.
Port Blair . . .	29·873	+·060	SW	12	10·3	82·7	8	2·43	
Diamond Island . . .	29·860	+·013	SE	21	6·8	81·4	7	0·29	Sea rough.
Bassein . . .	29·863	+·087	SE	7	3·5	82·6	8	0·21	
Rangoon . . .	29·921	+·091	ENE	7	4·2	75·2	10	0·21	Drizzling rain.
Thayetmyo . . .	29·868	+·059	SE	1	5·0	86·1	6	0·24	Passing showers.
Akyab . . .	29·812	+·007	ESE	4	3·0	87·7	4	0·21	
Chittagong . . .	29·811	+·014	Calm	2	4·5	86·2	4	...	
Burrisal . . .	29·797	+·006	E	3	...	87·7	0	...	
Dacca . . .	29·801	—·006	ENE	1	4·6	89·0	4	...	
Jessore . . .	29·804	+·005	E	3	...	88·3	4	...	
Calcutta . . .	29·790	+·001	NE	3	4·6	87·0	7	0·09	
Saugor Island . . .	29·776	—·010	ENE	8	9·4	85·4	7	...	Sea very smooth.
Midnapore . . .	29·805	+·007	NE	4	...	86·5	4	...	
Balasore . . .	29·800	+·027	NE	2	...	86·5	4	...	
Cuttack . . .	29·769	+·003	Calm	1	2·6	84·0	8	...	
False Point . . .	29·758	—·025	NE	7	7·7	86·8	7	...	
Gopalpur . . .	29·752	—·007	N	2	8·5	85·6	8	0·02	Sea rising.
Vizagapatam . . .	29·758	+·009	NE	2	2·5	84·5	7	0·30	
Cocanada . . .	29·755	+·013	NNE	9	?	80·5	10	1·25	Sea very smooth.
Musulipatam . . .	29·709	—·037	NW	4	?	81·0	?	0·16	
Madras . . .	29·807	+·016	W	5	6·7	88·0	3	...	
Negapatam . . .	29·836	+·004	W	2	5·5	87·5	5	...	
Trincomalee . . .	29·865	—·008	W	?	15·5	89·0	6	...	
Galle . . .	29·924	+·018	NNW	13	8·5	81·0	9	0·48	
Colombo . . .	29·916	+·016	WSW	14	8·4	83·0	10	0·21	Overcast; passing showers.

These observations show that though, undoubtedly, the cyclone had formed in the middle of the Bay, and had become rather fierce, and though the weather was, in consequence, very stormy over a large portion of the sea area, nevertheless at the coast stations, and over the land portion of India, it had changed very slightly. Over Northern India pressure had scarcely changed; and light north-easterly winds and slight showers of rain only were reported at several stations. In Bengal the pressure had risen slowly, and the winds had become strongly easterly and north-easterly; and at the coast stations around the Bay, a fairly complete cyclonic circulation of winds had been established, though, in the majority of instances, the winds were very light. Thus, at Diamond Island, the wind was south-easterly, at Akyab east-south-east, at Burrisal and Jessore east, from Calcutta down to Cocanada north-east, from Masulipatam southwards more or less westerly, while at Port Blair and Nancowry it was from south-west. The greater part of this wind circulation was light, but at the southern Ceylon stations, and in the rear of the storm at Port Blair and Diamond Island, strong winds continued to blow.

The pressure variations on the coast, towards which the storm was advancing, were very small; and the largest fall, on the west coast of the Bay, in the 24 hours preceding 10 A.M. of the 21st, was 0·037" only, *viz.*, at Masulipatam. At False Point, the fall was only 0·025", and at Cuttack, near which also the centre of the storm subsequently passed, the pressure had risen 0·003". To the east and south of the storm, the barometer was rising more or less rapidly, and at Diamond Island the rise was more than one-tenth of an inch. This was of course due to the movement of the storm in a north-westerly direction. With the exception of these comparatively small changes, the coast and other land stations gave no indication of the violent action which was taking place in the Bay, and of the rapidly increasing and intense storm which then existed, and was rapidly approaching the Orissa coast.

In the Bay there were a considerable number of vessels, but unfortunately only two or three were at all close to the path of the advancing storm, and though these are sufficient to indicate the line of its advance, the position of the centre, and the precise barometric depression at the centre of the storm on this day are not ascertainable with such clearness and in such detail as could be desired.

The following table contains the extracts from the logs of all the ships navigating the Bay on the 21st September; and the distribution of pressure and the wind directions in the Bay of Bengal and in Bengal are shown in Plate VI:—

21st September 1885.

NAME OF SHIP.	POSITION AT NOON.		Barometer reduced to 32° and corrected as far as possible to 10 A.M.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
Goa	At Masulipatam		29° 82'	4 A.M., variable	5	Cloudy sky, with thunder and lightning from NW.
				8 A.M., NNW	5	
				Noon, NNW	4	Clear sky and fine.
				4 P.M., W by S	3	
				8 P.M., SW	3	
				Midnight, SW	3	

THE FALSE POINT CYCLONE OF

NAMES OF SHIPS.	POSITION AT NOON.		Barometer reduced to 31" and corrected as far as possible to 10 A.M.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>S.S. City of Agra</i>	?	?	29°68"	4 A.M., NE. 8 A.M., NE. Noon NE. 4 P.M., NE. 8 P.M., E. Midnight E.	4 5 6 6	4 P.M.—Dark cloudy weather; drizzling rain. 8 A.M. Sky overcast, rain at times, and high sea. Noon. Heavy squalls. 4 P.M. Similar wind and weather. 8 P.M. Heavy squalls with rain; overcast sky and high confused sea. 10 P.M. Navigating by soundings.
<i>Minnyhive</i>	12° 35' N.	89° 36' E.	29°78"	4 A.M. 8 A.M., SSW Noon, SW 4 P.M.	 4 ...	Very bad weather; dense clouds rising from NW to NE and tearing in shreds overhead, with terrible vivid lightning, but not much wind. Wind always between SSW and W. Heavy rain at times.
<i>Nancowry</i>	12° 19' N.	93° 07' E.	?	4 A.M., S 8 A.M., S Noon, S 4 P.M., S 8 P.M., S Midnight, S	2 3 3 2 3 1	SE swell. Occasional heavy rain; squalls. Overcast.
<i>Saint Marcock</i>	13° 58' N.	82° 36' E.	29°87"	4 A.M., SW Noon, SW	4—6 ...	Overcast, with heavy rain, heavy lightning to NW, and banks of clouds passing over from NW, without the wind changing.
<i>Cuthona</i>	13° 57' N.	88° 15' E.	29°90"	4 A.M., WSW Noon, WSW 4 P.M. to Midnight, SW	... 9 10 ...	Smooth sea. Very heavy rain, with squalls and thunder and lightning. Set upper topsails reefed, lowering them down in squalls. Reefed fore sail.
<i>Blairgowrie</i>	15° 56' N.	89° 29' E.	29°58"	4 A.M., S 4 W 8 A.M., S 4 W Noon, S 4 W 4 P.M., S 3 W 8 P.M., S 6 W Midnight, S 6 W	5—7 8—7 8—7 7—8 8—7 8—2	Moderate to fresh gales; strong squalls NW; sea getting up; lightning and thunder. P.M. looks very bad at times; took in upper topsails.
<i>Favonius</i>	15° 59' N.	85° 32' E.	?	4 A.M., SW 8 A.M., SW Noon, SW 4 P.M., SW 8 P.M., SW Midnight, SW	6 6 6 6 6 6	Fresh to strong gales. Very cloudy and squally, and very high, cross sea.

NAMES OF SHIPS.	POSITION AT NOON.		Barometer reduced to 32° and corrected as far as possible to 10 A.M.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Britannia</i>	20° 21' N.	87° 25' E.	29.56"	4 A.M., ENE 8 A.M., NE by N Noon, NNE 4 P.M., NE 8 P.M., E. Midnight	3 4 6 6 7 10	From noon to midnight of 21st wind hauled from NNE to E. increasing in force at 1 A.M. of 22nd; blowing hurricane force up to 3 A.M., had half hour calm, when wind came out of west, backing to SW with terrible force, and blew up to 6 A.M. At 8 A.M. of 22nd barometer 29.20.
Schooner <i>Kunt Alfasson</i> .	17° 4' N.	87° 4' E.	...	?	...	A.M. morning calm up to 3 A.M., then wind north and north-west. Small breeze later on; raining, but mostly from north and round about north, with squalls and rain, freshening to a stiff breeze from N.W., with squall and rain. No observations taken at noon. During the afternoon, the wind was getting gradually stronger from N.W. with continually fresh squalls and immense quantity of rain. Later on continually freshened to a terrific gale and the wind at 4 P.M. at west. at 7 P.M. WSW. At 10 P.M. SW; the sea very high, the ship was closed, hauled on the port tack; but at 6 P.M. kept her off to the N.E. with all sails fast, except the fore lower topsail. Water discoloured, having appearance of blackishness; sounded but got no bottom with 90 fathoms. Rain pouring down continually in immense quantity all the time without ceasing and the gale blowing in terrific puffs and the sky showed intense darkness; the sea very turbulent and high, and the barometer continually going down.
<i>Quang Tung</i>	19° 53' N.	89° 11' E.	29.65"	4 A.M., E by S 8 A.M., ENE. Noon, E by S 4 P.M., E by S 8 P.M., E by S Midnight, ESE	4 5 8 9 8 8	2 A.M. Dark detached clouds rising and passing over from the south-eastward rapidly. 4 A.M. Sea smooth. 6 A.M. Furlled forward awnings. 8 A.M. Moderate north-easterly sea and swell. 9-15 A.M. Wind and sea rapidly increasing; very heavy south-easterly sea; eased and brought to. 10-35 A.M. Proceeded on course; furlled all awnings. Noon. Very heavy sea. 3 P.M. Very hard squalls from the eastward, with a very heavy sea, shipping much water; hove to. 4 P.M. A heavy sea struck the port forward sponson house, smashing it completely in, washing away Engineer's bath-room and W.C. and sponson planking. 8 P.M. Very hard squalls from the eastward, heavy sea and swell. Midnight. Very heavy confused sea.

THE FALSE POINT CYCLONE OF

NAMES OF SHIPS.	POSITION AT NOON.		Barometer reduced to 32° and corrected as far as possible to 29 in.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
Barque <i>Rollo</i>	16° 10' N.	88° 00' E.	29° 55"	8 A.M., NW Noon, NW by W 4 P.M., W 8 P.M., SW 12 P.M., SSW	Increasing force. Gale Strong gale. Strong gale. ...	Midnight. Baffling winds and rain. A.M. Wind increasing NW and much rain. Noon. Freshening gale, NW by W. Rain. 4-30 P.M. Strong gale from west; high confused sea. 8 P.M. Wind backing to SW, strong gale and rain with high sea. Midnight. Wind SSW, less wind.
<i>Gouverneur Wilmot</i>	15° 19' N.	92° 9' E.	29° 76"	4 A.M., S 8 A.M., S Noon, SSW 4 P.M., S by W 8 P.M., S	8	Squally with heavy showers of rain. Set lower topsail and foresail. 8 A.M. clear set top sails and top-gallants. Noon, squally, rain in gusts. 4 P.M. Constant heavy rain, but barometer very steady; 8 P.M. reefed topsails. Sea rough. Midnight, hard squalls and lightning to WNW.
Barque <i>Cynosure</i>	16° 20' N.	88° 52' E.	29° 56"	8 A.M. Noon, NW	... ...	Light, variable airs from north and west; wind increasing with heavy squalls and rain. Later, fresh gusts with hard squalls; wind backed to SW.
<i>Calcutta</i>	16° 50' N.	89° 32' E.	29° 41"	Forenoon to 2-30 P.M. NW by W to W by S 6 P.M., SSW, and finally to S by E	Gale ...	Terrific squalls with a regular downpour of rain. Noon, no observations. Barometer at its lowest (29° 26") with the wind at W. 2-30 P.M., weather breaking up; barometer risen 0° 05'; wind veering to SW; kept ship off N by E to run, but after running about 8 miles found the barometer commence to fall, and hove ship to on port tack as before. 6 P.M., wind SSW, and still veering; barometer again rising. The sea all this time seemed to come from all quarters. Heavy spray coming on board, first from one place and then another. The wind veered to S by E, a fine steady gale.
<i>Clan MacIntosh</i>	19° 35' N.	86° 47' E.	29° 77"	4 A.M., N 9 A.M., NNE 1 P.M., NNE 4 P.M., NNE 8 P.M., N	... ... ... ... ...	From midnight to 4 A.M. Light variable wind and cloudy; sea smooth. 4 A.M. light variable wind and cloudy; sea smooth. 8 A.M. freshening breeze with dark gloomy weather. 8-30 A.M. violent squalls with heavy rain. Noon, strong breeze with heavy squalls of wind and rain. P.M. Strong increasing gale, with wild confused sea, and heavy squalls of wind and rain. Ship straining and rolling heavily. Sent down cargo derricks, also foretop gallant yard, and secured everything about the decks.

NAMES OF SHIPS.	POSITION AT NOON.		Barometer reduced to 31" and corrected as far as possible to 10 A.M.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Clon MacIntosh</i> — contd.	...	...	...	10 P.M., NNW	...	2-30 P.M. slowed the engines ; carefully watching the weather.. 3-30 P.M. wind and sea still increasing. • Master and officers, after careful consideration, agreed that the ship was approaching the vortex of a cyclone, and decided to run to the SW. 4 P.M. turned ship round, and set course S 43° W. Full speed the engines. 5 P.M. put ship head to sea to secure cargo adrift below. 5-40 P.M. advanced ; proceeded full speed. Pumps and fire precautions attended to. Midnight, strong gale with terrific squalls and torrents of rain, and wind blowing at times with hurricane force. Wild confused sea. Steamer labouring and straining heavily, and shipping large quantities of water fore and aft.

The *Booldana* was at False Point anchorage, and for this day its observations have no special value, as the False Point observatory gives all the observations that are required. The *Goa* was off Masulipatam, and gives no information of value; the *Nancowry* was to the east of the Andaman Islands, and beyond the fact that she experienced moderately strong southerly winds with heavy rain squalls and a south-easterly swell, this vessel gives no information. To the west of the Andamans the *Minnihive* experienced south-westerly winds of force 4, with very bad weather, dense clouds rising from north-west to north-east, and tearing in shreds overhead, with "terrible vivid lightning." A little further north, were the *Cuthona* and the *St. Marnock* which experienced very strong south-westerly winds with heavy rain and squalls. A little further north and west, was the *Favonius*, which reports strong south-westerly winds, squally weather with high cross sea. These vessels all appear to have been outside the actual storm area, and to have been but little influenced by the cyclonic circulation of winds round the centre ; but they experienced these exceptionally strong winds and bad weather from the enormous indraught then taking place towards the storm itself. All the other vessels, of which observations are given in the above table, seem on this day to have been within the actual influence of the cyclone. The *Governor Wilmot*, which on the previous day had been not very far from the centre of the storm, was to-day in 15° 19' N lat. and 92° 9' E long., that is, far in its rear ; and she merely experienced strong south-south-westerly winds, with hard squalls and heavy rain. The *Blairgowrie* was near the centre of the Bay, her position being 15° 56' N and 89° 29' E, and she experienced moderate to fresh gales, with wind from south by west, with strong squalls, and a north-westerly sea getting up. The Barque *Rollo* was a little more to the east, her position being in 16° 10' N and 88° 0' E at 12 o'clock on the 21st, and in the early part of the day, had wind increasing from the north-west and much rain. In the afternoon the *Rollo* experienced a freshening gale, north-west by west, and at 4 P.M. a strong gale

from the west, with a falling barometer and high confused sea. At 8 P.M. the wind was backing to south-west, with a strong gale, and rain and high sea, and at midnight it was south-south-west. From these observations, it is clear that at noon on the 21st, the storm centre was considerably to the north, and a little to the east of the position of the *Rollo*, and that it passed nearly due north of the ship at about 4 P.M. Probably, then, it was approaching longitude 88°E at 4 P.M. on the 21st.

The *Cynosure* was in $16^{\circ}20'\text{N}$ and $88^{\circ}20'\text{E}$ at noon on the same day, and was therefore some 50 or 60 miles nearer the centre than the *Rollo*. Here somewhat similar changes were experienced. The day opened with variable winds from north and west; at 12 o'clock the wind was increasing from north-west, with heavy squalls; later a fresh gale was blowing with hard squalls; and then the wind went round to south-west. Clearly, at noon, the centre of the cyclone must have been nearly in a north-easterly or north-north-easterly direction from the *Cynosure*.

Again, nearer to the centre of the storm than the *Cynosure*, was the *Calcutta*, the position of which at noon is given as $16^{\circ}50'\text{N}$ and $89^{\circ}32'\text{E}$ by dead reckoning.

Assuming this position as correct, this vessel was about 50 miles NE of the *Cynosure*. The day commenced on the *Calcutta* with terrific squalls; with wind at first NW by W, then changing gradually through W to W by S, with a regular downpour of rain. Shortly after noon, the barometer was at its lowest (probably about $29\cdot26''$ corrected to 32° and sea-level), when the wind was west. At 2.30 P.M. the weather was "breaking up," barometer rising and wind veering to SW; and finally, at 6 P.M., wind was SSW, with extremely heavy sea; then the wind settled down into a steady gale S by E.

These changes show, with the greatest clearness, that the *Calcutta* cannot have been very far to the south of the storm centre, at about noon on the 21st. The barometer being lowest and wind W at noon, shows that the centre was then nearly to the north; and from the fact that wind finally went rapidly round through SW to S by E, it would appear that the ship must have been comparatively near, if not very near, the centre. The lowest barometric reading registered on board the *Calcutta* was $29\cdot26''$. The position laid down for the ship is probably fairly accurate, and thus at 10 A.M. the centre of the cyclone must have been N by a little E of this position. This gives its position at that hour as between $17^{\circ}15'$ and $17^{\circ}30'\text{N}$ lat. and $89^{\circ}45'\text{E}$ long.; and therefore the distance, travelled by the storm in the previous 24 hours, would have been about 180 miles. Hence the storm had been travelling, from 10 A.M. of the 20th to 10 A.M. of the 21st, at the rate of 7 or 8 miles an hour.

Considerably to the west of the advancing storm was the *Kunt Alfsson*. No observation of position could be taken on board this vessel on the 21st, but dead reckoning gave $17^{\circ}04'\text{N}$ and $87^{\circ}04'\text{E}$. On this vessel it was calm up to 3 A.M., when it began to blow from the north, and then shifted to the NW. During the afternoon, the wind got gradually stronger from the NW, with fresh squalls and an immense quantity of rain; it freshened continually to a terrific gale; and at 4 P.M., it became west. At 7 P.M. it became WSW, and at 10 P.M., SW, blowing a gale with terrific puffs the whole time. The sea was very turbulent and high and much discoloured. Rain was pouring down continually in immense quantity. The lowest barometer reading recorded was, so far as can be judged, when corrected with the best data available for this ship, $28\cdot79''$ reduced to 32° and sea-level on the afternoon of this day. It would therefore appear

that this vessel was nearer the centre of the cyclone, during the afternoon from 4 to 7 P.M., than the *Calcutta* had been, or else that the depression at centre of the cyclone was rapidly deepening. The centre evidently passed to the north of this ship about 5 P.M. of this day, and at this time probably the centre of the storm was about in $18^{\circ}30'$ or $18^{\circ}45'N$ and about $88^{\circ}15'$ or $88^{\circ}30'E$. It would therefore appear that the velocity with which the storm was moving had increased considerably, and that it was then moving at the rate of 12 or 13 miles per hour.

To the north-west of the *Kunt Alfsson*, the *City of Agra* crossed the path of the advancing cyclone, and, in the earlier part of the day, experienced north-easterly winds of force 4 to 5, changing to an easterly wind at 4 P.M. with force 6. The barometer was steadily falling the whole time, but the lowest reading was not till 4 P.M. of the 21st. This steamer experienced heavy squalls with rain, with a high confused sea, but, being a powerful steamer, was able to force its way across the front of the advancing cyclone, and was well to the north of the centre when the storm advanced towards the land.

The *Clan MacIntosh*, on the voyage from Madras to Calcutta, apparently obtained observations on the 21st, and fixed her position at noon as $19^{\circ}35'N$ and $86^{\circ}47'E$. She was coming up the Bay to the west of the *City of Agra*, and was probably steaming more slowly, for, unlike the *Agra*, she was unable to pass entirely across the advancing storm, but nearly steamed into it, and had to reverse her course and run to the SW in order to avoid it. When, however, the *Clan MacIntosh* reversed her course, as shown in the extracts of the log given above, she would appear to have been a little to the north of the central line of advance of the storm, and thus, in the forenoon probably, the steamer passed across the central track of the storm, while in the afternoon she re-crossed it. This steamer, therefore, experienced first a northerly, and then a N.N.E. wind; and, on returning, she passed back from the N.N.E. wind through N. to a N.N.W. wind; and when, during the night of the 21st, the storm advanced towards the Orissa coast, she was about 80 miles to the south of the track of the centre. The weather which she experienced, in her double passage through the outer part of the advancing storm was of course very bad, and of the same general description as that quoted in previous cases, *viz.*, "a strong gale with terrific squalls, the wind being of hurricane force, with a wild confused sea, and torrents of rain, &c."

The next log of interest, on this day, was that of the Indian Government steamer *Quang Tung*, which had left the Sandheads on the previous night, bound for the Andaman Islands. The steamer was therefore running a course about S. by $38^{\circ}E$. At 8 A.M. on the 21st, she met an E.N.E. wind, and at 9-45 A.M., the wind and sea were rapidly increasing, and a very heavy southerly sea was running; at 10 A.M., her position was $19^{\circ}56'N$. lat. and $89^{\circ}07'E$. long.; at noon, the wind became easterly, and the position of the ship being about $19^{\circ}53'N$. lat. and $89^{\circ}10'E$. long, it was then clear that the vessel was passing towards the east of the storm centre; the wind force then continued to increase, there being, at 3 P.M., very hard squalls from the eastward, with a very heavy sea; and at 4 P.M., a very heavy sea struck the port forward sponson house, smashing it completely, and washing away sundry deck-houses. The barometer continued to fall till about 4 P.M., when the position of the vessel is given as $19^{\circ}46'N$. and $89^{\circ}16'E$. After this, the barometer began to rise, though the weather still continued very bad. The gradual

fall of pressure up to 4 P.M. was probably due to the fact that the vessel was still steering towards the track of the cyclone; for these observations, when considered as a whole, tend to show that the centre of the cyclone was probably almost due south of the *Quang Tung* between 10 and 12 o'clock, or, say, about 11 o'clock on this day, and nearly in $89^{\circ}10'$ E. This, it will be seen, agrees well with the position at the same hour, deduced from the *Cynosure* and *Calcutta* observations. The *Quang Tung* never approached very near to the centre of the storm, and at 12 o'clock was probably 100 or 120 miles away from it. At this time, the vessel had slowed down to about a mile an hour, and thus allowed the centre of the storm to cross her course and pass away.

It will be seen that these observations enable us to trace the course of the cyclone up to 4 P.M. of the 21st. On this day, the ship *Britannia* lay directly in the track of the storm, as she was making slow progress up the Bay. The position of the ship is very clearly marked, as observations were obtained at noon on the 21st, and again on the 22nd. Those taken at noon on the 21st, showed her position to have been $20^{\circ}12'$ North latitude and $87^{\circ}25'$ East longitude, and those on the 22nd, $20^{\circ}12'N$ and $87^{\circ}6'E$. In other words, the ship's position was nearly constant, for the 24 hours during which the storm advanced towards her. The centre passed over her at about 3 A.M. of the 22nd, and then proceeded on over the land. During this time, she was almost stationary at about 40 or 45 miles to the east-south-east of False Point, the land station over which the storm burst. The Master, Captain John Shaw, has been good enough to give a description of the weather he experienced at this time, and it is here appended in full:—

"Ship *Britannia*, 21st September, in lat. at noon, $20^{\circ}21'$ North long. $87^{\circ}25'$ East.

"Wind then north-north-east, strong and squally; passed the ship *Champion*, going to the south-south-west ward. 2 P.M. furled top gallant sails, wind about north-east; strong and heavy squalls. Bar. low at 4 P.M.; wind increasing; furled the courses, bar. 29.50; a very high sea from south-east.

"At 3 P.M., wind now east, blowing hard; furled upper topsails, bar. 29.40 at 10-30, wind increasing with much rain; furled lower topsails, bar. 29.20; midnight, blowing hurricane; much lightning; from 1 to 3 it blew terrific; bar. going down to 28.20 ($28.16''$ corrected), which was the lowest; aneroid 27.50", much agitated; the lightning very vivid in the height of gale, and so much rain falling we could not see the masts and yards. At about 3 A.M., calm for about half an hour; the aneroid much agitated during the calm; the wind came out of west with terrible force, and backed afterwards to south-west, and blew up to 6 A.M., hurricane force with much rain and lightning. One hour after the shift of wind, the bar. began to rise.

"At 8 A.M., blowing a hard gale from south-west with high sea; at 9 A.M., ship driving into coloured water; sounded 30 fathoms. Read bar. 29.20; noon got lat. $20^{\circ}12'$ (?); after got long. $87^{\circ}6'$; at 1 P.M., 22nd, ship driving amongst a lot of people who clung to hatches and spars and life buoy; put one of the life boats out, and picked up the mate and one man belonging to the ship *Merchantman*, of Calcutta, which ship foundered at 4 A.M., 22nd, east-south-east, 20 miles off False Point; saw others floating round, but could not render any more assistance, the boat being amongst them. During the gale we lost our fore and main top gallant masts, and yards with the heads of the topmasts; lower fore topsail yard; truss of foreyard gave way; foretop much damaged, and other damage to spars, masts, and the whole suit of sails blew away from the yards, except mainsail and jib, and these were damaged. The wind kept south-west and south-south-west, which brought us up to the Eastern Light on the 23rd at noon, and got Mr. Collingwood, Pilot, on board. This is as correct a statement as I can make of the cyclone."

JOHN SHAW.

The position, given for the *Britannia*, is about 220 to 230 miles north-west of the position of the storm at 10 A.M., on the 21st, and as the centre of the storm passed over the *Britannia* at 3 A.M., in 15 hours the storm had advanced about 225 miles, or at the rate of nearly 15 miles an hour. It has previously been shown that, from about 10 A.M. to 6 P.M. of the 21st, the velocity of the storm was about 13 miles an hour; and it would therefore appear that the rate of movement of the storm was increasing at this time. Captain Shaw gives the duration of the calm to be about half an hour; and hence it may be inferred that the central calm was probably not more than 7 or 8 miles across. It will further be noticed in this report, that the wind having been east, when the calm centre advanced over the ship, and due west when she passed out of it, it would seem that the ship passed nearly directly across the centre. The lowest barometer recorded in the *Britannia*, and corrected as far as possible for temperature and the error of the instrument, was 28.16", which is very much lower than any previously registered in this storm, showing that the storm was rapidly intensifying in its forward progress towards the land.

The storm has thus been traced up to about 45 miles east south-east of False Point, where its centre lay at 3 or 3.30 A.M. of the 22nd. The next observations, which show the positions and track of the storm, are those of the *Booldana*, then lying at False Point anchorage, which vessel was carried forward a considerable distance by the storm wave. This anchorage is about 7 miles to the north-east of the light house and Meteorological Observatory at False Point. The observations made on board this steamer will be found later on, under the table giving the sea observations of the 22nd. The weather is described as follows:—

"2 A.M.: Gale with increasing squalls.

"3-30. A.M.: Heavy squalls; blowing a very heavy gale.

"4 A.M.: Wind and rain still increasing.

"6 A.M.: Wind NNE to NE.

"6-15 A.M.: A lull; the weather cleared up, with clear sky overhead, but round the horizon all dark.

"7 A.M.: Gale came down from opposite quarter with double force, making it impossible to stand on deck without holding on. Wind SW.

"9-45 A.M.: The force of the gale gradually abated; noon fresh squalls."

The lowest barometrical reading was taken at 7 A.M., and was 27.4", which, after correction, will probably be about 27.39". This, again, is very considerably lower than the record on the *Britannia*, and it again shows that, in the progress of the storm towards the land, it was undergoing an extremely rapid increase in intensity and force. The duration of the central calm is here given as 45m; which, if the storm was travelling at the rate of about 13 or 15 miles an hour, would give the diameter of the central calm as 9 or 10 miles. It must however be observed that the *Booldana* was carried forward bodily by the storm wave, over shoals where ordinarily there is only a few feet of water, which might make the centre calm appear longer, and therefore of greater diameter than it really was. It would appear also, from the directions of the winds before and after the calm, that the centre of the storm passed almost precisely over the ship.

In the remarks above quoted, it will be seen that the full force of the gale lasted from 2 A.M. to 9.45 A.M., or nearly 8 hours; and as the storm was travelling at the rate of about 13 or 14 miles an hour, the actual storm or "gale centre," as it might be called, could not have been more than about 100 to 110 miles across.

The observations of the *Booldana*, though extremely valuable, are however eclipsed in importance by those made at the False Point Meteorological Observatory, where an experienced observer, Mr. Workman, was in charge. Mr. Workman, seeing that a cyclone was approaching that station, commenced early, taking a series of observations and barometric readings, which are extremely valuable.

In the preceding paragraphs, the history of the storm has been traced up to the False Point anchorage, where it passed over the *Booldana*. The light-house at False Point is situated to the south south-west of the anchorage, and at a distance probably of about 7 miles, and the evidence of Mr. Workman's observations would appear to show that, though the calm centre passed over the light-house, the Meteorological Observatory lay to the south of the precise central line of the storm, and, therefore, the duration of the calm was rather shorter at the observatory than on board the *Booldana*. The following is the report drawn up by Mr. Workman :—

False Point.

"The weather began to assume a threatening appearance between 4 and 5 P.M. of the 21st September 1885, the wind being from the NE and blowing fresh, in squalls, with a heavy, overcast sky, and heavy banks of clouds rolling up from the NE. At 6 P.M. I commenced sending you bi-hourly observations, and continued doing so until 2 A.M. of the 22nd. After that, all communication by telephone was stopped. Your telegrams for the 16 and 22 hours' observations I did not receive until 8 P.M. The weather continued the same, with the wind increasing in force and the squalls more frequent, and still from the NE, until between 1 and 2 A.M. of the 22nd, when it was blowing a gale, and at 4 A.M. the wind had increased to a hurricane, and the squalls were most terrific, with blinding sheets of rain, still from the NE, and the barometer falling rapidly. 6-30 A.M. hurricane still blowing, but wind hauled to the NW, when it suddenly lulled, and became almost a calm; 6-50, the wind had shifted to the WSW, and blew again with redoubled force, the gusts being most terrific. At 7 A.M. the barometer began to rise again rapidly until 10 A.M., when the wind had moderated down to a gale, and at noon it was blowing a fresh breeze from the SW, with squalls. During the first part of the cyclone, when the wind was from the NE, the anemometer was blown away from the top of the pillar, and the ladder was lifted out of its step and thrown down; the anemometer we picked up some distance away, all broken and unfit for further use. During the lull in the wind we saw that the thermometer shed was shaking, so we took out all the thermometers, and luckily we did so, as, with the first gust of wind from the WSW, the shed came down. The tidal wave or water rose several feet and inundated the grounds round the light-house for miles, and all the trees and jungle are stripped to bare stumps, and many of them up-rooted altogether. The harbour station at Hookeytolla has been completely washed away and many people drowned; the Port Officer, his wife and family, are, I regret to say, among the number. The following are the readings of the barometer taken during the storm :—

Time and date.	Actual Bar. reading.	Temperature, attached thermometer.	Reading reduced to 32° and sea-level.
6 P.M. of the 21st	29.705	81.0°	29.603"
8 " " "	29.727	81.8°	29.622"
10 " " "	29.691	82.0°	29.556"
Midnight "	29.599	81.0°	29.496"
2 A.M. of the 22nd	29.461	81.2°	29.360"
4 " " "	29.223	79.8°	29.126"

Time and date.	Actual Bar. reading.	Temperature, attached thermometer.	Reading reduced to 32° and sea-level.
5 A.M. of the 22nd	29'113	No observations of attached thermometer were taken in these readings, but a temperature of 80° has been assumed, which will give a number approximately accurate in the last column.	29'016"
5-30 " " "	28'850		28'723"
6 " " "	27'782		27'690"
6-30 " " "	27'223		27'135"
7 " " "	27'240		27'154"
7-30 " " "	27'870		27'778"
8 " " "	28'961		28'865"
8-30 " " "	29'234		29'136"
9 " " "	29'340		29'241"
9-30 " " "	29'445		29'346"
10 " " "	29'497		29'398"
Noon " " "	29'628		29'528"
2 P.M. " " "	29'626		29'526"
4 " " "	29'644		29'544"

This represents an extremely valuable series of observations, both of the general conditions and wind changes, but particularly of the barometric readings. It is, however, to be regretted that the readings of the attached thermometer of the barometer were not taken after 4 A.M. of the 22nd: but any possible error arising from this omission is small; and assuming that the temperature was about 80°, the possible error of the pressures recorded, when reduced to 32° F. and sea-level, is not greater than a few, probably about five-thousandths of an inch. The extraordinarily low reading of 27'135" was recorded at 6-30 A.M. of the 22nd at the commencement of the central calm, while, at 7 A.M., at the end of the calm, the pressure was 27'154". This is the lowest pressure ever recorded in a cyclonic storm in the Bay of Bengal,¹ and the reading is perfectly free from doubt; it was made with an instrument which had been carefully verified at the Alipore Observatory, and its correction for altitude above sea-level is also known. The correctness of the reading is consistent with the fact that there was a graduated increase in the rapidity of the fall with the approach of the storm centre, as is seen in the above record; also, the two observations at 6-30 and at 7 A.M. tell the same tale; while the readings are confirmed by those taken on board of the *Booldana* a few miles to the north. It is easy to suggest a possible explanation why the readings in the ship did not go quite so low as those in the observatory, for marine barometers are always more or less sluggish in their action, and the conditions under which barometric measurements can be made in a steamer, even though at anchor, during a cyclone, are vastly more difficult than those under which similar observations can be made in an observatory, where measurements can be recorded

¹ It appears to be the lowest on record, in any part of the world.—*Ed.*

to a thousandth of an inch; but, on the other hand, it is quite possible that the lowest barometric reading was not quite co-incidental with the centre of the cyclone, and the two readings, *i.e.*, on the *Booldana* and at the Observatory, may be equally accurate. There is then no reason to question the trustworthiness of this reading of $27\cdot135''$, when reduced to 32° F and to sea-level; and there remains only a possible error in the reduced reading of a few thousandths of an inch, according as the temperature of the barometer was a few degrees above or below 80° F.

This reading appears to be the lowest recorded in any storm in the Bay of Bengal, or in Indian Seas; for all the cyclones, of which any accurate records exist, are given in Blanford's Catalogue of Cyclones in the Bay of Bengal,¹ and here the lowest barometric reading given is that of the Midnapore Cyclone of October 13th to 16th, 1874, where the central calm passed over the Sandheads, and a reading of $27\cdot58''$ was obtained. Even in the great cyclone of October 2nd to the 5th, 1864, which caused a storm wave in the Hooghly, swept away 48,000 souls, and upwards of 100,000 cattle, stranded nearly all the shipping in the river; landed the Peninsular and Oriental Mail Steamers *Bengal* and *Bentinck* hulk, high and dry in fields; and stripped all trees of their leaves;² the lowest barometric reading recorded at Calcutta was only $28\cdot570''$.

The positions of the *Booldana* and the False Point Observatory were probably about 7 miles apart, and while the central track of the cyclone passed only slightly to the south of the *Booldana*, the False Point Observatory was considerably to the south of this line; for immediately before the calm, the wind was north-west, and after it had passed over, it came from the W.S.W. The duration of the calm was therefore necessarily smaller at the observatory than on board the *Booldana*, and only lasted about 20 minutes. As the rate of advance of the storm was about 13 miles an hour, this would give the transverse dimension of the part of the central calm, which passed over the False Point Observatory, as only 4 or 5 miles. At first sight it would appear that the times at which the calm passed over the two places were different, but the difference is easily explained. The telegraph officer in charge of the False Point Observatory has probably used Madras time, which is that always worked with in that Department, while the time given in the *Booldana's* log is local time. There is a difference of nearly half an hour between the two times, the telegraph time being behind the local time.

Again, on the *Booldana* no mention is made of the storm-wave having been noticed, while at the observatory the wave was very marked; but after the storm was over, it was found that the *Booldana* had been bodily carried over shoals, on which there are ordinarily only a few feet of water. The storm-wave not having been noticed in the *Booldana*, it is clear that the wave must have risen very gradually, but with irresistible force, and both the upward and forward movements must have been so gradual that, being in open water, the *Booldana* noticed neither.

The False Point Observer records that the wind had strengthened to a gale at False Point at 2 A.M., and that at 10 A.M. it had again fallen to the force of an ordinary gale, while at noon it was only blowing with that of a fresh breeze. The duration of the storm's violence was therefore about 8 or 9 hours, and since its rate of progress was about 13 or 14 miles an hour, this gives a storm diameter of between 104 and 126 miles.

¹ Journal of Asiatic Society, Bengal, Vol. XLVI, Part II, p. 328.

² *Ibid.*

which agrees very closely with the measurement deduced from the record of the *Booldana*.

The cyclone having thus passed over False Point, it continued to advance in a north-westerly direction, and passed to the north of Cuttack. This station felt the storm comparatively little, as will be shown by the following statements of the observations, at the Cuttack Meteorological Observatory:—

Cuttack.—The horary readings of the 21st September were completed at midnight, when the barometer stood at 29'660" (attached thermometer 82'0°), heavy rain, which measured 1'06 inches, was falling, with a light breeze from the north.

At about 3 A.M. the wind from the north began to increase, and so continued till 7 A.M., when its rate was about 6 miles per hour, backing from north to south-west, which latter direction it kept till the storm had passed over.

At 8 A.M. the barometer read 29'200", which was the lowest point it fell to, with attached thermometer 77'0° (barometer reduced to 32° and sea-level = 29'160").

At 9 A.M. it had risen to 29'250", and at 10 A.M. it read 29'270".

The greatest wind velocity was between 10 and 11 A.M., when it blew at the rate of 40 miles an hour.

The lowest barometric reading at Cuttack was between 8 A.M. and 9 A.M.; the pressure did not begin to rise till 9, and up to 10 A.M. had risen only slightly; so that the storm centre was probably nearest this station at 9 A.M. Hence it would appear that the central calm was nearest to Cuttack $2\frac{1}{2}$ hours after it had passed over False Point. Now the point on its line of advance at which the storm centre would be nearest to Cuttack, would be about 40 miles from False Point; and according to its previous rate of progress, more nearly 3 than $2\frac{1}{2}$ hours after its passage over False Point.

The lowest barometric reading at Cuttack was only 29'2 (reduced to sea-level and $32^\circ = 29'16''$), or two inches higher than that recorded at the central calm at False Point; hence it is clear that the centre was never very close to Cuttack. It is to be inferred from the readings taken at the False Point light-house and the rate of progress previously deduced, that a reading of 29'2" would correspond to a distance of about 26 to 30 miles from the centre of the storm, and assuming that it continued to advance in a straight line on its former path, which appears to have been about North 45° or 47° West, the path of the storm should have brought its centre within 40 or 45 miles from Cuttack. This seems too considerable a difference to be accounted for by inaccuracy in the observations, and the conclusion I incline to is that in its advance over the land the storm had already lost something of its barometric intensity. The length of time, too, during which the barometer at Cuttack remained comparatively steady, that is, from 8 A.M. when it read 29'200", to 10 A.M. when it read 29'270", appears to show again that the intensity of the depression at the centre of the storm was decreasing, and that in its passage over the land the storm was becoming rapidly enfeebled. At 10 A.M. of the 22nd, the centre was probably about 45 miles to the north-east of Cuttack; and indeed the outer edge of the intense gale circle was rapidly approaching this station.

The restricted dimensions of the storm, and the comparative smallness of the area of country affected by it, will be seen from the following table, in which the 10 A.M. observations of the 22nd are given for the stations, previously selected, to illustrate the meteorology of Upper India, on the days during which the cyclone was forming; also those taken

at several additional stations in Bengal, and representing very fully the Meteorology of the province during the advance of the storm:—

September 22nd.

STATIONS.	Barometer reduced to 31" and sealevel.	Change since previous day.	Wind direction, 10 A.M.	Wind velocity in miles per hour for previous 24 hours.	Normal velocity, September, miles per hour.	Temperature, 10 A.M.	Cloud proportion.	Rainfall in inches.	REMARKS.
Lahore . . .	29'881	+ '006	W	2	2'0	88'2	0	Nil	Fine clear weather.
Delhi . . .	29'863	+ '015	N	3	3'9	87'2	0	Nil	Ditto.
Lucknow . . .	29'848	+ '024	E	3	2'7	86'1	9	Nil.	
Ajmere . . .	29'885	+ '010	NE	8	4'7	84'3	0	Nil.	
Allahabad . . .	29'821	+ '028	NE	?	2'7	85'7	9	0'02	Fine weather, with passing clouds.
Nagpur . . .	29'765	+ '009	Calm	2	4'7	85'2	5	0'28	Fine clear weather.
Bombay . . .	29'878	+ '017	NNW	13	12'0	81'5	10	0'09	
Nancowry . . .	29'890	+ '021	SSW	4	9'6	81'0	7	1'09	Partial clouds.
Port Blair . . .	29'960	+ '087	SSW	6	10'3	83'7	7	0'07	Ditto.
Diamond Island . . .	29'962	+ '101	SSE	13	6'8	83'4	7	0'41	Sea slight.
Bassein . . .	29'947	+ '084	SSE	8	3'5	84'7	7	0'39	Partial clouds.
Rangoon . . .	29'982	+ '061	SSE	?	4'2	78'1	8	0'78	
Thayetmyo . . .	29'968	+ '070	S	4	5'0	85'1	5	Nil	Sultry.
Akyab . . .	29'950	+ '138	ESE	7	3'0	81'6	10	0'37	
Chittagong . . .	29'927	+ '116	SSE	2	4'5	78'7	10	0'01	
Dacca . . .	29'878	+ '077	ESE	3	4'6	84'4	9	0'07	
Jessore . . .	29'829	+ '025	ESE	8	...	82'0	10	0'47	
Calcutta . . .	29'737	+ '053	E	9	4'6	79'5	10	0'62	
Saugor Island . . .	29'650	+ '126	SE	17	9'4	80'4	10	2'94	Sea rising.
Midnapore . . .	29'685	+ '120	NE	10	...	78'6	10	2'31	
Balasore . . .	29'511	+ '289	ESE	12	...	79'5	10	4'25	
Cuttack . . .	29'230	+ '539	NW	5	2'6	76'5	10	3'18	
False Point . . .	29'401	+ '356	SW	?	7'7	?	8	3'99	Squally, overcast, gloomy.
Gopalpur . . .	29'637	+ '115	SW	6	8'5	78'5	10	1'00	Sea rising
Vizagapatam . . .	29'746	+ '012	W	2	2'5	84'0	9	Nil.	
Cocanada . . .	29'749	+ '006	W	6	7'0	82'0	7	2'26	Sea very smooth.
Masulipatam . . .	29'751	+ '042	NW	5	?	84'5	10	Nil.	
Madras . . .	29'822	+ '015	W	5	6'7	86'5	7	0'49	
Negapatam . . .	29'871	+ '035	W	2	5'5	88'5	5	Nil.	

STATIONS.	Barometer reduced to 32° and sea-level.	Change since previous day.	Wind direction, 10 A.M.	Wind velocity in miles per hour for previous 24 hours.	Normal velocity, September, miles per hour.	Temperature, 10 A.M.	Cloud proportion.	Rainfall in inches.	REMARKS.
Trincomalee . .	29.860	—'005	W	?	15.5	88.0	8	Nil.	Continuous rain. Overcast.
Galle . . .	29.971	+ '047	WNW	15	8.5	80.5	6	2.25	
Colombo . . .	29.977	+ '061 ₇	SSW	13	8.4	78.5	8	0.45	
Burdwan . . .	29.791	—'061	E	5	3.3	79.4	10	0.17	
Berhampore . .	29.837	+ '037	E	5	3.6	81.3	10	0.91	
Serajgunge . .	29.880	+ '073	NE	?	?	81.5	9	0.09	
Rampore Beaulah .	29.835	+ '039	E	7	?	82.6	6	0.52	
Dinagapore . .	29.844	+ '027	E	14	?	81.7	7	Nil.	
Kungpore . . .	29.901	+ '086	SE	3	?	84.7	7	0.28	
Jalpaiguri . .	29.909	+ '096	SE	3	?	82.5	4	Nil.	
Darjeeling . . .	*23.093	+ '042	NE	1	3.2	61.0	7	0.11	Drizzling, partial clouds. Overcast, gloomy, drizzling.
Furneah . . .	29.878	+ '058	ESE	1	2.4	85.6	9	Nil.	
Durbhunga . .	29.851	+ '027	ESE	3	3.6	86.0	5	Nil.	
Motiharee . . .	29.827	+ '019	ESE	6	?	88.1	9	Nil.	
Bhagalpur . . .	29.821	+ '032	ESE	2	?	?	5	Nil.	
Patna	29.820	+ '008	E	2	3.0	88.6	5	Nil.	
Arrah	29.824	+ '002	E	3	?	85.7	5	Nil.	
Buxar	29.800	—'001	ENE	6	?	88.4	7	Nil.	
Dehree	29.799	—'014	E	9	?	87.4	6	Nil.	
Gya	29.780	+ '002	ENE	2	2.3	85.4	10	0.14	
Hazaribagh . .	29.790	—'009	ENE	7	7.0	75.5	10	0.45	Drizzling, partial clouds. Overcast, gloomy, drizzling.
Ranchee	29.732	—'048	NE	9	?	73.0	10	0.25	
Chybassa . . .	*28.873	—'157	NE	5	?	74.8	10	0.65	

* Not reduced to sea-level.

Beyond Orissa, and the adjacent parts of South-West Bengal and Chutia Nagpur, the whole of India was nearly unaffected by the cyclone, though a strong current was blowing in its rear, and the weather had become more cloudy over Bengal generally. With but few exceptions the wind directions also over the whole of Bengal conformed to the cyclonic circulation, though they were not strong.

As the storm on this morning had almost entirely passed inland, it is not necessary to give the very numerous observations which have been recorded from the logs of ships navigating the Bay for the whole of September 22nd, but in the following table are given some extracts from the logs of a few ships in the Bay which will indicate the general character of the weather over the sea area:—

THE FALSE POINT CYCLONE OF

22nd September 1885.

NAME OF SHIP.	POSITION AT NOON.		Barometer reduced to 55" and corrected as far as possible to 10 A.M.	Wind.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
S.S. <i>City of Agra</i>	?	?	29°64"	4 A.M., ESE 8 A.M., ESE Noon, ESE 4 P.M., SSE 8 P.M., SSE Midnight, SSE	7 7 6 6 6 4	Overcast sky and heavy squalls, with rain and high confused sea. Noon. Weather clearing up. 5 P.M. received pilot and proceeded for Saugor. Midnight. Moderate and cloudy squally looking weather.
<i>Minnyhive</i>	13° 32' N.	88° 26' E.	29°82"	Noon, SSW	...	Weather still wild-looking, but beginning to assume a better aspect. Clouds getting gradually less dense ahead. Sky clearing away.
<i>Governor</i>	8° 45' N.	82° 58' E.	29°92"	4 A.M., S 4 W 8 A.M., S 4 W Noon, S 4 W 4 P.M., S 4 W 8 P.M., S 4 W Midnight, S 2 W	4 2 3 2 0 4	Sea rough all day, going down at night; a heavy swell from SE-ward. Sky clear, with passing clouds.
<i>Saint Marnock</i>	16° 20' N.	88° 34' E.	29°83"	4 A.M., NW 8 A.M., SSW 8 P.M., S	8 4 to 6	Northerly sea; running down against strong SW wind and sea. Strong breeze and squally. Sky overcast. 4 A.M. Had hard squall from north-west, lasted 40 minutes. Dark, dirty threatening weather to northward; heavy lightning to north-west.
<i>Blairgowrie</i>	18° 49' N.	91° 9' E.	29°77"	4 A.M., S 2-6 W 8 A.M., S 6-2 W Noon, S 2-1 W 4 P.M., S 3-3 W 8 P.M., S 3-1 W Midnight, S 1 W	7-6 6-7 6 6 6-5 5-7	Moderate gale; squally; vivid lightning W and N. Nasty cross sea NW, W and SW. Looks very dirty to NW of us; squalls rising from W.
<i>Favonius</i>	15° 59' N.	85° 32' E.	?	4 A.M., SW 8 A.M., SW Noon, SW 4 P.M., SW 8 P.M., SW Midnight, SW	7 7 7 7 3 7	Very high sea and very cloudy; sea running from all directions, and sky very dark to the N. Shortened sail, expecting a very heavy squall from N. at any minute.
<i>Barque Rolfo</i>	18° 17' N.	88° 55' E.	29°50"	.....	...	At midnight of 21st, wind SSW and less wind. Barometer rising. Forenoon set all sail. At noon, strong westerly set.

NAME OF SHIP.	POSITION AT NOON.		Barometer reduced to 32° and corrected as far as possible to 10 A.M.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Governor Wilmot</i>	17° 40' N.	90° 3' E.	29° 84"	4 A.M., S by W 8 A.M., to Noon, SSW 4 P.M., S 8 P.M., SSE	7 7 strong breeze.	4 A.M. Very squally and constant rain. Sea moderate, set sail. Noon. Clear strong sea breeze NW. 4 P.M., awful sea from NW; had to furl topsails, fear ship would jump masts out.
<i>Barque Cynosure</i>	16° 52' N.	89° 10' E.	29° 56'	8 A.M., SW Noon, SSW 8 P.M., SSW	... ... ...	First, fresh gale and heavy squalls. Do. wind and weather. Later, more moderate; weather clearing.
<i>Calcutta</i>	19° 28' N.	90° 13' E.	29° 30"	Noon, W to S by E	...	Got on soundings at midnight. Kept the lead going every half hour. Took all sail off but lower topsails to wait daylight. 4 A.M. hauled sharp on a wind standing E in 10 and 22 fathoms Running up to make Lower Gasper. Lead constantly going. Got into Western channel. Found I was shoaling and in keeping off took the ground but got off at night, losing stream and one bower anchor in doing so.
<i>Schooner Kunt Alfson.</i>	19° 17' N.	86° 42' E.	?	.....	...	Wind SSW. At 4 A.M. the wind a little more moderate. Forenoon, a strong gale, with strong puffs and large quantities of rain pouring down and the sea high. Later on the wind going down to a fresh breeze from SSW. Cloudy sky. No observations taken at noon. Afternoon: wind southerly; steady, fresh breeze, 8 knots an hour; sky overcast. Water discoloured; no bottom got at 90 fathoms. Barometer gradually going up. Luffed up WNW.
<i>Quang Tung</i>	19° 24' N.	89° 30' E.	29° 70"	4 A.M., S by E 8 A.M., S 10 A.M., S Noon S 4 P.M., S by W 8 P.M., S by W Midnight S by W	8 7 8 6 6 6	Morning: vessel working a good deal and trembling fore and aft; deck also working; coal bunker lids started from their places, leaded galleys crushed up. 4 A.M. Very heavy confused sea. Daylight found cement of water ways broken by working of the ship. Very hard squalls with rain. Heavy SSE sea. 10 A.M.: heavy confused sea and very hard squalls from the southward. 11 A.M. Weather moderating, set on course again. 4 P.M.: Wind and sea moderating. 8 P.M.: wind and sea moderating.

THE FALSE POINT CYCLONE OF

NAME OF SHIP.	POSITION AT NOON.		Barometer reduced to 31° and corrected as far as possible to 10 A.M.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Clan MacIntosh</i>	18° 58' N.	86° 36' E.	29.68"	1 A.M., NW 2 A.M., NW 3 A.M., NW 4 A.M., WNW 6 A.M., W 8 A.M., WSW Noon, WSW 1 P.M., SW 5 P.M., S	... • •	From midnight gale still increasing and wind blowing at times with hurricane force; also vivid lightning with torrents of rain. High confused sea. Ship labouring and straining, and shipping quantities of water. Wind still heavily to the westward. Wind moderating and sea less confused. 5-50, turned ship round and set to. N 24° E by 47 miles. 8h., still blowing strong, with hard squalls and rain. Ship rolling and straining and shipping water. Noon. Fresh gale with violent squalls of wind and rain. Weather still threatening; ship going half-speed. 1 P.M. Heavy roll; cumulus clouds forming and passing away. 2.30 very threatening appearance to WNW (along the west). Bar. keeping steady at 29.75, but inclined to fall. Wind strong and steady from SW. Weather looking fine to the eastward. Altered course N 53 E, to see if we can run into finer weather towards the middle of the Bay. 4 P.M. full speed. 8h., fresh gale with hard squalls of wind and rain; heavy sea; ship straining and rolling heavily. Midnight, still blowing strong, with heavy cross sea; ship rolling and swinging heavily.
<i>Booldana</i>	?	False Point anchorage.	?	1 A.M. NNE to NE by E 4 A.M., NNE to NE by E 5 A.M., NNE to NE 7 A.M., SW 9 A.M., SW 8 P.M., SW 9 P.M., SW	9-10 11	2 A.M. Gale increasing; squalls with light rain. 3-30 A.M. Heavy squall with wind blowing a very heavy gale. 4 A.M. Wind and rain still increasing. 6-15 A.M. A lull. The weather cleared up, with clear sky overhead, but round the horizon all dark. 7 A.M. Gale came down from opposite quarter with double force, making it impossible to stand on deck without holding on. 9-45 A.M. The force of the gale gradually abated. Noon. Fresh squalls from SW. 4 P.M. Weather finer, but still blowing fresh from south. 8 P.M. Fresh breeze, with squalls at times.

From the data it will be seen that heavy weather prevailed over the northern half of the Bay, particularly near the Orissa coast, and that over the southern part of the Bay a strong monsoon current was blowing and the sea was rough. But, except near the Orissa coast at 10 A.M. of the 22nd, all evidence of a violent storm had virtually disappeared from the Bay. The distribution of pressure and the wind directions over the Bay of Bengal, and in Bengal, at 10 A.M. of the 22nd September, are given in Plate VI.

The rainfall accompanying the storm in its passage over the land was not so heavy as is generally recorded in such violent cyclones, and the heavy rainfall was almost entirely confined to the immediate track of the storm. The general rainfall of the province on this day is shown, as on previous days, in the form of a table, where the average rainfall at all the stations in each Meteorological District is summed up:—

METEOROLOGICAL DISTRICT.	Number of Stations from which average is obtained.	Average rainfall of District in inches for September 22nd.
Orissa	18	3'52
South-West Bengal	59	1'11
East Bengal	36	0'13
North Bengal	32	0'30
North Behar	24	0'17
South Behar	38	0'38
Chutia Nagpur	24	1'33

During the 24 hours, from 6 P.M. of the 21st to 6 P.M. of the 22nd, there was therefore very heavy general rain in Orissa and moderately heavy in Chutia Nagpur and South-west Bengal, while elsewhere the fall was only slight.

The track of the storm lay principally through the Cuttack and Balasore Districts in Orissa, and these recorded the heaviest falls; thus, in the Cuttack District, Jagatsingpur recorded 6'11 inches, Kendrapara 5'50 inches, Jajpur 5'00 inches, Cuttack 4'72 inches, Salipur 3'35 inches, and Banki 3'26 inches; while in the Balasore District, Bhudruck recorded 5'40 inches, Balasore 4'15 inches, and Chandbali 3'90 inches. At False Point the rainfall was 3'99 inches. In Chutia Nagpur the heaviest falls occurred in the south; at Hosseinabad, Ghatsila, and Baharagura the falls were between 3 and 4 inches.

The rainfall over these districts was therefore heavy, but not of extraordinary copiousness. It would appear from the report of the Collector of Balasore that the fall was heaviest in the interior, and particularly in the low hills across which the storm had to pass after leaving the coast, and before reaching Chutia Nagpur. The Collector of Balasore writes, "The rain-gauge at Balasore gives only some 6 inches for the storm, but the rain in the hills must have been extraordinarily heavy. All the rivers were in very high flood, and came out all over the country."

The central calm, or central path of the cyclone, having been traced to a position to the north-east of Cuttack at 10 A.M. of the 22nd, when it had apparently reached a point almost midway between Cuttack on the south and Balasore on the north, the storm continued its advance in a north-westerly direction during the remainder of that day. It is unfortunate that no stations of any considerable size lay directly in its path, and that no precise evidence of its continuous advance can therefore be obtained; but, judging from its previous line of advance, the central calm must have passed into the Tributary Mehals about noon on this day, and must have advanced between the high lands of Moarhanj and Keanjhar. It then passed into the south of Chutia Nagpur, *vis.*, into the Singbhum District, then to the south of Chybassa and Ranchee, and south-west of Hazaribagh, until finally, at 10 A.M. on the morning of the 22nd, the centre was in the north-west of Chutia Nagpur or in the south-west corner of South Behar.

Even though the exact position of the calm centre is not given by direct observation, the general position of the storm at 10 A.M. on this day, September 23rd, is shown very clearly by the land observations in the following table:—

September 23rd.

METEOROLOGICAL DISTRICT.	STATIONS.	Barometer, 10 A.M., re- duced to sea-level.	Change since 10 A.M. previous day.	Tempera- ture, 10 A.M.	Wind direction.	Air motion per hour of previous 24 hours.	Amount of cloud.	Rainfall since 10 A.M. of 23rd September
ORISSA	Gopalpur . . .	29'739	+102	83'6	S	21	8	0'21
	False Point . . .	29'783	+382	?	S	?	10	0'04
	Cuttack . . .	29'739	+509	87'1	S	11	6	1'64
	Balasore . . .	29'772	+261	84'5	S	17	6	1'46
	Midnapore . . .	29'705	+080	81'5	S	12	10	1'70
SOUTH-WEST BENGAL.	Saugor Island . . .	29'786	+136	85'4	SSE	30	8	Nil.
	Calcutta . . .	29'796	+059	83'5	SE	30	10	0'72
	Burdwan . . .	29'792	+001	83'9	ESE	8	10	0'93
	Bankoora . . .	29'407*	+062	81'9	SE	9	6	1'08
	Raneegunge . . .	29'384*	-074	79'4	SE	13	10	3'45
	Berhampore . . .	29'817	-020	78'3	ESE	12	10	0'45
	Kishinagore . . .	29'728*	-003	82'7	SSE	16	9	1'07
	Jessore . . .	29'838	+009	83'0	SE	8	10	1'30
NORTH BEHAR	Purneah . . .	29'808	-070	76'6	ENE	5	10	0'80
	Durbhunga . . .	29'779	-072	74'9	E	12	9	1'31
	Motihatee . . .	29'733	-094	75'1	ESE	18	10	0'71
	Chupra . . .	29'470*	-149	78'1	ENE	9	10	1'11
SOUTH BEHAR	Bhagalpur . . .	29'769	-052	?	ESE	7	10	1'38
	Patna . . .	29'685	-125	79'6	E	8	10	1'01
	Arrah . . .	29'633	-191	77'7	E	15	10	1'75
	Buxar . . .	29'595	-205	79'5	E	19	10	1'60
	Dehree . . .	29'543	-236	76'4	E	11	10	1'15
	Gya . . .	29'605	-175	80'9	E	9	10	1'02
CHUTIA NAGPUR.	Hazaribagh . . .	29'637	-153	73'6	SSE	29	10	1'44
	Ranchee . . .	29'660	-092	72'7	SE	?	10	2'23
	Chybassa . . .	28'916*	+043	81'3	SSE	13	10	0'50
NORTH-WEST PROVINCES.	Lucknow . . .	29'772	-076	85'1	E	4	9	0'02
	Gorakhpur . . .	29'739	-101	74'6	ENE	4	9	1'12
	Jhansi . . .	29'748	-083	85'0	NNE	?	0	Nil.
	Allahabad . . .	29'683	-138	75'8	NE	?	10	0'03
	Benares . . .	29'595	-216	76'1	ENE	9	10	1'83

* Not corrected for altitude.

These observations show that the cyclone was still in existence, and that its centre lay to the south-west or west-south-west of Dehree in South Behar. From the position to the north-east of Cuttack which the storm had occupied at 10 A.M. on the 22nd, the distance to that probably occupied in the morning of the 23rd is about 300 or 320 miles. Notwithstanding, then, that it was now advancing over the land instead of over the sea, that the land surface was more or less hilly and broken, that the storm had rapidly diminished in force, it had continued to advance with almost the same rapidity as on the previous day, for a rate of progress of about 13 miles an hour would give a daily total of 312 miles; a number which agrees remarkably closely with the position of the storm as deduced from the above observations. It would, however, appear probable that the intensity of the storm had rapidly abated, and that it was becoming shallower and more diffused, for the lowest pressure recorded on this day, was at Dehree, which was the station nearest to the centre. It was only 29·543 inches, a pressure more than two inches higher than had been registered at False Point on the previous day, but only four-tenths of an inch higher than that registered at Cuttack.

With the advance of the storm over the land, while strong winds and somewhat squally weather still prevailed at the head of the Bay, and particularly near the Orissa coast, in the south and east of the Bay the weather had become moderate, and the winds in some cases even light and variable.

This is shown by the following two tables, the first of which gives the observations made at the coast stations, and the second a few observations extracted from the logs of various ships navigating the Bay of Bengal. The distribution of pressure and the wind directions over the Bay of Bengal and in Bengal are given in Plate VI :—

Meteorology of September 23rd.

STATIONS.	Barometer reduced to 32° and sea-level.	Change since previous day.	Wind direction.	Wind velocity per hour of previous 24 hours.	Temperature at 10 A.M.	Cloud.	Rainfall.	REMARKS.
Diamond Island	29·960	—·002	NE	5	82·4	5	Nil	Sea very smooth. Observatory blown down. Sea rising.
Akyab	29·959	+·009	ENE	4	82·6	6	0·06	
Chittagong	29·929	+·002	SE	4	83·2	5	Nil.	
Burrisal	29·878	+·078	S	7	84·2	6	0·30	
Dacca	29·887	+·009	SSE	7	85·9	6	0·88	
False Point	29·783	+·382	S	?	?	...	...	
Gopalpur	29·739	+·102	S	21	83·6	8	0·21	
Vizagapatam	29·779	+·036	SW	3	85·0	8	Nil.	
Cocanada	29·804	+·055	WSW	7	78·5	10	Nil.	
Masulipatam	29·805	+·054	NW	8	82·0	10	0·19	
Madras	29·896	+·074	W	7	87·0	5	Nil.	
Negapatam	29·914	+·043	SW	2	87·0	6	Nil.	
Trichcomalee	29·869	+·009	SW	?	89·0	10	Nil.	
Galle	29·958	—·013	WNW	14	81·0	6	0·45	

23rd September 1885.

NAMES OF SHIPS.	POSITION AT NOON.		Barometer reduced to 32° and corrected to 10 A.M. as far as possible.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Minnyhive</i> . . .	18° 23' N.	88° 30' E.	29° 86"	Noon, S	...	Steady winds at south; fine weather, sky clear. Sailed 4 hours through heavy ENE swell. Afterwards sea smooth.
<i>Governor</i> . . .	12° 53' N.	84° 35' E.	29° 91"	8 A.M., S 2 W Noon, S 3 W 4 P.M., S 4 W 8 P.M., S 2 W	4 5 4 2	Sea slight; a swell from the SE getting heavier at night; clear sky; light passing clouds.
<i>Nancowry</i> . . .	16° 34' N.	91° 57' E.	29° 93"	Noon, Calm	...	Fine weather.
<i>Saint Marnock</i> . . .	18° 41' N.	88° 19' E.	29° 82"	4 A.M., S	3 to 5	Confused sea. Weather fine.
<i>Favonius</i> . . .	20° 33' N.	87° 59' E.	?	8 A.M., SSW Noon, SSW 4 P.M., SSW 8 P.M., SSW	7 7 7 6	Heavy banks of clouds rising from NW, coming close to and breaking up and going back north. Northerly sea still coming down; moderate breeze and clear moonlight.
<i>Quangtung</i> . . .	18° 02' N.	90° 53' E.	29° 93"	4 A.M., SE by S 8 A.M., SEly Noon, SEly 4 P.M., Sly 8 P.M., Sly Midnight, Sly	4 3 4 3 2 3	Cloudy, dark appearance passed westerly. Weather beginning to look fine again and wind more moderate. Ends clear sky.
<i>Barque Rollo</i> . . .	20° 13' N.	88° 00' E.	29° 78"	.....	...	4 A.M. Sea smooth.
<i>Governor Wilmot</i> . . .	20° 36' N.	88° 13' E.	29° 80"	4 A.M., SSE 8 A.M., SSE Noon, SSE 4 P.M., SSE 8 P.M., SSE	7	8 A.M. Sea smooth; slight southerly swell. 4 P.M. Sea smooth. 8 P.M. Ditto. Midnight. Ditto.
<i>Barque Cynosure</i> . . .	19° 25' N.	89° 02' E.	29° 84"	8 A.M., S Noon, S 8 P.M., S	... ... ...	Fresh breezes south, and a high cross sea. All possible sail set. 4 A.M. Strong breeze but fine by NW swell. 8 A.M.: fresh breeze, no sea, all sail. Noon. Strong breezes.

The rainfall of the province from 6 P.M. of the 22nd to 6 P.M. of the 23rd was not so heavy as generally accompanies the passage of so violent a cyclone. It can be sufficiently shown by the average fall of each district, as in former cases—

Meteorological Districts.	Number of Stations from which average is obtained.	Average rainfall of District from 6 P.M. of 22nd to 6 P.M. of 23rd in inches.
Orissa	18	0·17
South-West Bengal	59	0·89
East Bengal	36	0·18
North Bengal	33	1·34
North Behar	24	1·93
South Behar	38	1·52
Chutia Nagpur	24	1·06

Heavy and general rain was therefore falling in North and South Behar, North Bengal and Chutia Nagpur, and moderate rain in South-West Bengal, while in Orissa and East Bengal the fall was light and scanty. Even along the path of the storm the falls were not particularly heavy, and only two stations, Dinapore and Chupra, recorded over 5 inches, though falls of between 3 and 5 inches were somewhat numerous.

Up to the morning of the 23rd, the storm had been travelling almost in a direct north-westerly direction, and on a path which, though not absolutely straight, was only slightly curved. At this time the course appears to have changed, and to have become almost northerly towards the hills. This change of direction, as well as the track of the storm for the previous 4 days, is shown in Plate VII. At the same time, under the influence of the outlying ranges of the Himalayas, the storm rapidly broke up and ceased to have any well defined centre, or in fact any definite character. On the morning of the 24th, beyond the existence of an area of slight barometric depression, near Gorakhpur in the North-West Provinces, the centre of which was perhaps between this station and Motiharee, and of a feeble cyclonic circulation of winds around it, the storm was practically extinct.

The general distribution of pressure on September 24th, and the general conditions over this part of India can be inferred from the observations given in the table below:—

METEOROLOGICAL DISTRICT.	STATIONS.	Barometer reduced to 32° and sea-level.	Change since previous day.	Wind direction.	Wind velocity per hour of previous 24 hours.	Temperature, 10 A.M.	Cloud.	Rainfall of previous 24 hours in inches.
NORTH BENGAL.	Bogra . . .	29°797*	+°002	SE	21	84°5	10	0°90
	Serajgunge . .	29°895	+°017	SW	?	83°5	7	0°42
	Rampore Beaulah .	29°838	—°007	SE	12	82°6	5	0°67
	Dinagapore . .	29°860	—°007	SSW	5	81°2	9	1°83
	Rungpore . . .	29°871	—°041	SE	6	80°2	10	1°09
	Jalpaiguri . .	29°914	—°011	NNE	7*	71°5	10	3°93
	Darjeeling . .	23°071*	—°016	E	5	59°5	10	7°98
NORTH BEHAR.	Purneah . . .	29°838	+°030	NE	3	77°6	10	6°97
	Durbhunga . .	29°816	+°037	ESE	16	76°4	10	4°40
	Motiharee . .	29°748	+°015	SSE	8	79°1	10	4°31
	Chupra . . .	29°595*	+°125	WSW	12	79°1	8	5°28
	Bhagalpur . .	29°791	+°022	SSE	4	?	5	0°13
SOUTH BEHAR.	Patna . . .	29°799	+°114	S	7	81°6	8	4°44
	Arrah . . .	29°800	+°167	SW	17	78°7	8	0°64
	Buxar . . .	29°777	+°182	W	24	79°0	10	1°81
	Dehree . . .	29°807	+°264	SW	19	82°4	4	1°90
	Gya . . .	29°790	+°185	S	10	83°4	10	0°07
CHUTIA NAGPUR.	Hazaribagh . .	29°802	+°165	WSW	17	78°0	10	0°19
	Chybassa . .	29°039*	+°123	SSW	4	84°0	7	0°05
	Ranchee . . .	29°799	+°139	SW	12	79°1	9	0°06
NORTH-WEST PROVINCES.	Lucknow . . .	29°751	—°021	ESE	5	81°2	10	0°56
	Gorakhpur . .	29°678	—°061	WNW	8	71°2	10	8°44
	Jhansi . . .	29°770	+°022	NE	?	84°5	0	Nil.
	Allahabad . .	29°779	+°096	NW	?	79°7	10	0°94
	Benares . . .	29°774	+°179	SW	10	79°6	10	1°25

* Not reduced to sea-level.

As already remarked, the above observations show that beyond the area of low pressure between Gorakhpur and Motiharee, the storm had almost entirely disappeared, and that beyond the very heavy rainfall which attended the disintegration of the storm, due to the upward movement of the moisture-laden current, the weather had become almost normal over the greater part of Bengal.

In the Bay, too, the weather had moderated rapidly, and a light south-west current was blowing over its whole area. This is shown by the two following tables; the first of which gives the Meteorological observations taken at a few of the coast stations round the Bay, and the second those taken on board some of the ships navigating the Bay. The distribution of pressure and the wind directions over the Bay are also shown in Plate VII—

September 24th.

STATIONS.	Barometer reduced for temperature and to sea- level.	Change since previous day.	WIND.		Tempera- ture, Dry bulb 10 A.M.	Cloud.	Rainfall.	State of the sea.
			Direction.	Mean motion of past 24 hours.				
Diamond Island	29.928	—0.32	NE	2	82.9	4	0.29	
Akyab	29.921	—0.38	SW	2	84.1	7	...	
Chittagong	29.932	+0.03	Calm	2	85.2	7	...	
Dacca	29.903	+0.23	SSE	5	86.4	8	...	
Jessore	29.878	+0.40	S	8	83.0	5	0.52	
Calcutta	29.859	+0.63	SSW	10	84.5	10	0.04	
Saugor Island	29.865	+0.79	S	21	85.4	6	0.92	Rough.
Midnapore	29.832	+0.67	S	9	85.0	4	0.22	
Balasore	29.854	+0.82	SSW	9	85.5	5	0.16	
Cuttack	29.832	+0.93	S	3	86.1	3	...	
False Point	29.856	+0.73	S	?	85.3	6	...	
Gopalpur	29.818	+0.79	S	21	85.1	5	0.87	Rough.
Cocanada	29.834	+0.30	WNW	5	81.5	6	...	Very smooth.
Masulipatam	29.828	+0.23	NW	6	87.5	9	...	
Madras	29.900	+0.04	WNW	6	87.0	5	0.04	
Negapatam	29.883	—0.31	W	2	87.5	2	...	
Trincomalee	29.872	+0.03	W	?	87.0	5	...	
Galle	29.938	—0.20	WNW	9	82.5	7	0.18	

24th September.

NAMES OF SHIPS.	POSITION AT NOON.		Barometer reduced to 35" and corrected as far as possible to 10 A.M.	WIND.		Weather during the day.
	Latitude.	Longitude.		Direction.	Force.	
<i>Minnyhive</i>	20° 16' N.	88° 12' E.	29° 87"	Noon, S. by W.	Light	Light winds and fine, with lightning at night at N.W.; passing rain showers. Sea smooth, found current setting to S.E. 22 miles throughout 24 hours.
<i>Governor Wilmot</i>	16° 49' N.	86° 30' E.	29° 90"	4 A.M., S. 2 W.	1	Sea smooth; a swell from S.E., heavy in the morning, going down at night; sky clear; light passing clouds, fine weather.
				8 A.M., S. 2 W.	1	
				Noon, S. 2 W.	1	
				4 P.M., S. 2 W.	1	
				8 „ South	1	
<i>Nancowry</i>	18° 08' N.	90° 21' E.	29° 94"	Midnight, Variable	1	Slight SW swell.
				8 A.M., Calm	1	
				Noon, Calm	1	
<i>Saint Marnock</i>	20° 40' N.	87° 33' E.	29° 88"	4 P.M., Calm	1	Weather fine.
<i>Barque Cynosure</i>	20° 52' N.	88° 19' E.	?	4 A.M., South	3 to 4	Moderate breeze and hazy.
				8 A.M., South		Ditto.
				Noon, South		Ditto.
				8 A.M., South	Moderate	Moderate breeze and clear, with fine weather.
				Noon, South		
				8 P.M., S.W.		
<i>Schooner Kunt Giffson.</i>	20° 38' N.	87° 42' E.	?	.....	Light	Wind south; and S.W.; fine breeze; small squalls, with little rain.

During the breaking up of the storm, the rainfall was particularly heavy along the line of the hills, and at stations in part of the North-West Provinces, North Behar, and North Bengal; rain was also fairly general in South Behar, but over the remainder of the province, it was light and scanty. The distribution is shown below in each of the seven districts here adopted—

METEOROLOGICAL DISTRICT.	Number of stations from which average is obtained.	Average rainfall of district in inches from 6 P.M. of 22d to 6 P.M. of 24th September.
Orissa	18	0·18
South-West Bengal	59	0·25
East Bengal	36	0·03
North Bengal	33	2·78
North Behar	24	4·03
South Behar	38	0·62
Chutia Nagpur	24	0·20

Darjeeling received 9'66 inches, and Mickligunge (Cooch Behar District) 9'45 inches, Gorakhpur 8'44 inches, and Kishengunge, Arrareah, and Purneah between 8 and 9 inches. The following stations had between 4 and 8 inches of rain:—Gajol, Raigunge, Dinagepore, Julpigoree, Cooch Behar, Matabhanga, Siliguri, Kalimpong, Kaleagunge, Durbhanga, Madhubani, Beheea, Sitamarhi, Mozzufferpore, Pooree, Bettiah, Bagsha and Gopalgunge. At Katmandu in Nepal also, 3'10 inches of rain was registered.

The storm, which had thus almost disappeared on the morning of the 24th September, had entirely ceased to exist on the 25th, and the weather conditions over the province of Bengal had become normal. It is therefore unnecessary to describe the detailed Meteorology of Bengal for any further period.

THE STORM-WAVE ACCOMPANYING THE CYCLONE, AND THE DESTRUCTION CAUSED BY THE ACTION OF THE CYCLONE GENERALLY.

It has already been mentioned, in the report of the Meteorological Observer at False Point, that a storm-wave overwhelmed that station at the time of the passage of the central calm, or possibly, almost at its close; this storm-wave, submerging the country, did an immense amount of damage, and caused a large loss of life. The damage done by the wave apparently far exceeded that due to the winds; but, fortunately, the extent of country affected by the wave was not large, and the loss of life was restricted to the vicinity of the central path of the storm, and to a district extending only a few miles inland from the coast.

The most complete account of the effects of the storm-wave,¹ and of the damage done by the storm generally, is to be found in a report written by C. T. Metcalfe, Esq., C.S.I., Commissioner of the Orissa Division. From this report it would appear that the greatest height of the storm-wave was 16 feet at Jumbo, and 15 feet at the False Point Light-house. The following are some extracts from Mr. Metcalfe's report:—

"The Cyclone on the Orissa Coast."

"The evening was a calm evening at Cuttack. Up to midnight there was a modified breeze from the east. While Cuttack was thus calm, the Bay was violently agitated with dirty heavy clouds overhead. The British India steam ship *Booldana*, lying outside the False Point harbour, was so knocked about that her commander brought her inside into the harbour. At 2 A.M. a heavy gale set in at False Point from the north-east. At 6-10, there was a complete calm at False Point. At 6-20, two hours before high tide, a tidal-wave swept over the False Point harbour, sweeping away all houses ashore; submerging Jumbo; then it rolled in one wide unbroken wave in a north-easterly direction over Kaldeep and Kerara, submerging villages and carrying away with irresistible force houses, cattle, human beings, deer, and other wild animals. At the light-house the wave lasted about a quarter of an hour, at Jumbo about two hours, and at places further north-east a less time. An examination of the country on the 24th showed that the wind (after the lull of the cyclone) from the south-west travelled with greater rapidity and violence than from the north-east. The trees were rendered leafless and charred as if scorched by a furnace.

¹ Since the text of this report was finished, and after Mr. Pedler's departure for Europe, a report on the storm-wave, illustrated by a chart, was received from Government. Some extracts from the former are given in the Appendix, p. 136, and a reduction of the chart on Plate VIII. The measured height of the wave above mean sea-level was greater than that assigned by Mr. Metcalfe, *viz.*, 21 feet at Jumbo and 22 feet at False Point.—*Ed.*

"The effect of the tidal-wave was suddenly to create a sufficient depth of water all over the harbour to float large steamers like the *Booldana* over shoals where ordinarily there is only a few feet of water. The sudden fall of the water landed the ships and steamers which had drifted from their moorings on to the shoals where they now lie, and landed the cargo barges in the midst of the jungle and in the most extraordinary places, the boatmen having no command whatever over their boats, and being unable to distinguish, amidst the wild waste of waters, the creeks from the submerged land. The villages near the coast were absolutely destroyed, the destruction of life decreasing with the depth of the water.

"*Effect of the wave at False Point.*—At False Point the height of the wave was calculated at about 15 feet. On Tuesday evening (the 22nd) 4 boatmen, who had escaped the cyclonic wave by taking refuge on the top of the refuge house, arrived at the light-house by walking and swimming, and reported to Mr. Workman what had happened. Their statement is that Captain Douglas was last seen on the roof of his house, but as the water rose, the roof collapsed. There were at the time of the cyclone on shore, Captain Douglas, his wife and three children; Mr. Mines, Assistant Port Officer, Mr. Fletcher, agent of Captain Bulloch, Port Master, one constable, Dāk Bungalow khansamah, sweeper, 18 boatmen (of whom 6 were saved), some 7 or 8 Nakoodah shippers, 1 ayah, 2 office peons, the captain of the *Tewkesbury*, and four European sailors, besides natives. The population was probably from 90 to 100 souls. The light-house moved under the force of the wind from side to side, leaning over 4 to 5 degrees. The light-house-keepers expected every moment that the house would fall. The wave lasted about one quarter of an hour.

"*Effect of the wave at Jumbo.*—There is a lock here at the terminus of the Kendrapara extension opening out into the Jumbo river. There was a lock-keeper, his wife and family, four khallasies, and a tindal. Several shop-keepers had houses near the lock. The tidal-wave reached Jumbo at 6.30 with the change of the wind to the south-west, passing over the lock above 15 or 16 feet, carrying away all the houses—toll-house carried away, leaving no vestige save a few bricks. Across the river opposite the lock is the village of Jumbo, with a double-storied-masonry house built for a telegraph office, a masonry store-house, and masonry post office elevated on a high mound. The native population of the village was about 130 souls. There were no Europeans or officials in the place. The tidal-wave reached the cornice of the lower story. Some 13 native villagers took refuge in the upper story, and one woman and a child. All the rest of the native population was swept away. On visiting the place on the 25th the village site was covered with the corpses of men, women, and children. Dead bodies were also floating in the creek before the village; numerous carcasses of cattle, deer, and huge fish lay about. It was a sad scene. The masonry walls of the out-houses had been laid flat, and the rooms of the store-room gutted by the water.

"*Effect of the storm on the country between Jumbo and the Brahmini, along the Hunsuā Creek.*—The country here is for miles quite flat, and at high tide only a few feet above the water. There is still a considerable area uncultivated, but the greater area is entirely devoted to rice, of which there was an excellent crop on the ground. The Hunsuā creek runs winding through villages which a few days ago were teeming with a prosperous population. The cyclone and the sea-wave combined have utterly destroyed trees, clumps of bamboos, houses, and cultivation. The trees look as if they had been scorched by a blast from a fiery furnace. Huge trees lie overturned, leafless with broken branches; houses crushed into one confused mass. The village sites being higher than the cultivation, stand out prominently amidst the wild waste of salt water which I found spread over the whole country. It is difficult to describe the scene, without drawing a graphic description of the aspect of the country, which presented the same picture as far as the eye could reach—the wild waste of waters with black shapeless hillocks which looked as if charred by fire. Here and there, in places, a solitary bullock, from time to time, lowing for a companion, standing alone, surrounded by the dead carcasses of a herd. Here and there a solitary human form standing out against the sky on the roof of a fallen hut. No sound, except the rush of water; no sound of cattle, birds, or of human voices; all life seemed crushed. The steamer in places literally ran through a succession of floating human bodies. The stench was sickening. The scene of desolation lasted as far as the Brahmini. Beyond that houses were roofless, and uprooted trees lay in every direction, but the scorch of the hurricane was wanting. No life had been lost, and the crops were safe.

"*Chandbally.*—I met here the Manager of the Kanika Estate. His statement, based on the re-

ports which had reached him, was that 700 villages in Kerara and Kaldeep had been completely wrecked, and three-fourths of the population completely destroyed. On entering the Hunsua, at the entrance to which the *S. S. Jack* was high and dry, the first recipients of relief were the pilgrim passengers by the *Jack* on their way to Pooree, and the unfortunate police constables at the Hunsua outpost. At Rajnugger I met one of the Court of Ward's officers, and learnt from him that Paraspor, Haldea, and some eight to ten villages nearer the coast had been entirely swept away, and not a soul saved. He had the statement from the people of Gurdeepore that half the population of Rajghar also had been drowned, 12 feet of water passing over the village. He calculated that 15 villages of Kaldeep had been clean swept away and totally destroyed in two hours, and also the village of Kudurichua, which we afterwards passed, and were able to verify the statement, for there was not even the vestige of a village. The following villages were also mentioned as totally destroyed:—Kajilichua and Arakdihi. The steamer ran through the jungle creeks and anchored for the night at Jumbo. Towards the early morning, with the tide falling, the stench of the corpses was dreadful. On our way back we passed the steamer *Eliza* lying in the False Point jungle, and later on one of Captain Bulloch's cargo-boats and the broken sides of a row boat."

Such being the damage done in Orissa, it might have been anticipated that considerable damage would also have been done in some of the districts of Chutia Nagpur, but no reports of any such have come to hand, and it would therefore appear that in passing through Chutia Nagpur the storm was of comparatively little force.

In Tirhoot, however, on the 23rd, the storm apparently did a certain amount of damage, though on a small scale. The *Indian Planters' Gazette* describes its effects in uprooting trees and blowing down houses, &c., in certain small localities, but this would appear to be only the final efforts of the storm or perhaps local offshoots from the storm, the strength of which was perhaps increased by the heaviness of the rainfall which was taking place in Behar at that time.

THE BAROMETRIC PRESSURES RECORDED DURING THE CYCLONE.

It has already been mentioned that some extraordinarily low pressures were recorded during the passage of the cyclone, and that at False Point a reading of 27.135" (corrected to 32" and sea-level) was recorded during the central calm. This observation is certainly correct within a few thousandths of an inch; the observation was taken by an experienced and careful observer, with an instrument which had been accurately verified, and the elevation of which above sea-level had been precisely determined. Moreover, the observation is confirmed by the readings taken on board the *Booldana*, lying in the harbour, about 7 miles from the Observatory. No equally low pressure has ever been recorded in any previous cyclone in Indian seas, even in the most extensive and disastrous; the lowest pressure previously recorded being 27.58" in the Midnapore cyclone of 1874. In addition, however, to this feature of interest, the central calm having passed over a well-equipped Meteorological Observatory, at which careful barometric records were kept during the whole passage of the storm, and having also passed near several other stations, at which Meteorological observations are regularly kept, an excellent opportunity is afforded by this cyclone for discussing the distribution of pressure in such storms. For two or three days the forward movement of the storm seems to have been very regular, and to have averaged about 13 miles an hour; also the direction of its movement was very uniform; for a long time almost in a straight line.

Taking, in the first place, the series of barometric observations made at False Point Observatory, which are given at page 102. At False Point, the central calm set in at

¹ See footnote, page 103.

6-30 A.M., and ended at 6-50 A.M., so that 6-40 A.M. may be taken as the time of passage of the central point of the storm.

In the following table are given the readings obtained at definite intervals before and after the passing of this centre, together with their difference from the lowest observed :—

BEFORE STORM CENTRE.				AFTER STORM CENTRE.			
Time of observation.	Time before passage of centre of storm.		Barometric reading in inches.	Difference from lowest point in inches.	Difference from lowest reading in inches.	Barometric reading in inches.	Time after passing of centre of storm.
	Hrs.	Min.					Hrs. Min.
21st, 8 P. M.	10	40	29'622	2'487	2'409	29'544	9 20 4 P. M., 22nd.
21st, 10 "	8	40	29'556	2'421	2'391	29'526	7 20 2 " "
21st, Midnight	6	40	29'496	2'361	2'393	29'528	5 20 12-0 " "
22nd, 2 A. M.	4	40	29'360	2'225	2'263	29'398	3 20 10 A. M., "
22nd, 4 "	2	40	29'126	1'991	2'106	29'241	2 20 9 " "
" 5 "	1	40	29'016	1'881	2'001	29'156	1 50 8-30 " "
" 5-30 "	1	10	28'723	1'588	1'730	28'865	1 20 8-0 " "
" 6-0 "	0	40	27'690	0'555	0'643	27'778	0 50 7-30 " "
" 6-30 "	0	10	27'135	...	0'019	27'154	0 20 7 " "

From these figures it will be seen that, in close proximity to the centre of the cyclone, the fall and rise of pressure are almost equal for equal intervals of time before and after its passage; so that, at equal distances from the centre, the pressures are approximately equal; but it also appears that, in the outer circles of the cyclone, the pressure fell less rapidly in the front, than it rose in its rear; in other words that, in the outer circles of the cyclone, the baric gradient was less steep in front than in rear. It is true that, in the above table and in the diagram, no account has been taken of the diurnal oscillation of pressure, but even when this is allowed for, the fact remains. This is probably accounted for by the fact that, in front of the advancing storm, the atmosphere is in a more or less quiescent condition, and the advance of the body of the storm into such an atmosphere, heaps up the air in front of it, and thus tends in the first instance even to cause an increase in the pressure, notwithstanding the approach of the cyclone. It may be mentioned that in the case of some of the smaller cyclonic storms such as are sometimes formed in the rainy season in the Bay of Bengal, I have observed a similarly distinct, but slight, rise of pressure in front of the advancing storm.²

The distribution of pressure in this cyclone may perhaps be most satisfactorily studied on the morning of the 22nd, when the cyclone was about 45 miles to the north-east of Cuttack. A reference to the chart of this day, Plate VI, will show that the isobars were nearly circular, being only slightly elliptical in the direction of the storm's path. It is a fact of considerable importance that, even in so violent a storm as that under review, wherein the barometric pressure fell to nearly 27 inches, the gradient is

¹ This is shown clearly in the diagram (Plate VII), where the pressures recorded in the previous table are graphically shown.

² Mr. Pedler has not cited instances, which is to be regretted, as it is not clear how long before the arrival of the storm this phenomenon is considered to have manifested itself.—*Ed.*

uniform around the storm centre; for this information may be of considerable use in foretelling the line of advance in any particular storm.

One point of great interest in this storm is the steepness of the barometric gradient, shown by the pressure observations of False Point. Since the storm was travelling at a mean rate of about 13 miles an hour, and the lowest pressure recorded at False Point was $27\cdot135$ ", it results from the previous table that, in the half hour immediately before the calm, there was a fall of $0\cdot555$ inch, and in the half hour again preceding, a fall of $1\cdot033$ inches; that is to say, within 13 miles of the central calm, there was a fall of $1\cdot588$ inches, or $0\cdot12$ inch, per mile; and in the interval ($6\frac{1}{2}$ miles) between distances of 13 and $6\frac{1}{2}$ miles from the central calm, the fall was not less than $0\cdot16$ inch in each mile of the storm radius. Expressed in terms of time, in the half hour, 5.30 A.M. to 6 A.M. the pressure fell at the rate of a tenth of an inch in every three minutes. So steep a baric gradient, so rapid a fall of pressure, has probably never before been recorded; and there is no reason to doubt its correctness.

Taking the vortex of the cyclone to have been about 100 or 120 miles across, as inferred from the data in the previous part of the paper, there was a fall of about $2\frac{1}{4}$ inches of pressure from its outside edge to its centre. For the pressure at False Point at 2 A.M. of the 22nd, 4 hours 40 minutes before the passage of the centre was $29\cdot360$, and as that at the calm centre was $27\cdot135$, there was a fall of $2\cdot225$ inches in 4 hours 40 minutes. In the rear of the centre, at 10 A.M. of the 22nd, or 3 hours 20 minutes after its passage, the reading was $29\cdot238$, or $2\cdot263$ above the minimum. The storm was moving at the rate of about 13 miles an hour, so that, in front of the centre, the fall was $0\cdot031$ per mile on an average of the vortex of the storm, while in its rear the rise was $0\cdot053$ " per mile.

When contrasted with the distribution of pressure in European storms, the above facts are very striking. Mr. Buchan mentions¹ the case of a severe storm on 6th February 1867, when at Greenwich the pressure was $28\cdot859$ ", at Paris $29\cdot607$ ", and at Lisbon $30\cdot420$ "; during which, high winds and stormy weather prevailed over this area, and the anemometer at Lloyd's registered a velocity of 84 miles an hour. Now these figures give a maximum gradient of about three thousandths of an inch per mile only, or one-fourteenth of the general baric gradient of the False Point cyclone, and one-fiftieth of its steepest gradient, *vis.*, between 13 and 6 miles from the central calm.

Again, in the great hurricane which swept over Scotland on January 24th, 1868, Mr. Buchan shows the steepest gradient to have been about 1 inch in 72 miles,² or $\cdot014$ " per mile, and points out that the force of this hurricane was sufficient to blow down houses, etc., in Edinburgh; but even the maximum gradient in this storm was only about a third of the mean gradient in the False Point cyclone, and only a tenth of its maximum gradient.

In tropical storms previously recorded, baric gradients, greater than those of the European storms just quoted, have been observed; thus, in the cyclone which passed over Nassau in the West Indies, on 1st October 1866, a gradient of one inch in about twenty-nine miles is computed³ from the observations in some parts of the storm. But even this appears small in comparison with the maximum gradient in the False Point cyclone, which is four or five times as great.

Again, one of the most rapid falls of pressure ever recorded hitherto, happened during the hurricane which devastated Guadeloupe on the 6th September 1865, and when at Marie Galante there was a fall of 1'693 inches in an hour and ten minutes; but here again the small False Point cyclone takes precedence, with a recorded fall of 1'033 inches in 30 minutes, and a rise of 1'087 inches also in 30 minutes. In these several features the False Point cyclone appears to have been the most extraordinary storm on record.

THE WIND DIRECTIONS AND VELOCITIES IN CONNECTION WITH THE STORM.

The general wind directions and cyclonic circulation, during the formation and advance of the storm, have, to a great extent, been discussed in the preceding pages; but in the case of the False Point cyclone, there are some extremely valuable wind observations available, which have not yet been referred to. The history of the storm is, indeed, quite unique in the fact that no less than 5 anemographs, at various meteorological stations, were within measurable distance of the storm. One, situated at Rangoon, gives valuable information as to the period of its formation; and of the other four, that at Cuttack was in the western quadrant of the storm, and those of Saugor Island, Calcutta, and Hazaribagh were at different times in the eastern quadrant. Cuttack was considerably nearer to the centre of the storm than the other three, but all give valuable information.

The following table gives the hourly wind directions and velocity as measured by the Rangoon anemograph for the 18th, 19th, and 20th September 1885:—

Date.	Times.	0 to 1.	1 to 2.	2 to 3.	3 to 4.	4 to 5.	5 to 6.	6 to 7.	7 to 8.	8 to 9.	9 to 10.	10 to 11.	11 to 12.
September 18th	Wind direction . . .	WSW	NW	NNE	NNE	NE	NNE	NNE	NNE	NNE	NNE	NNE	NNE
	Velocity, miles per hour . .	5	6	6	4	6	6	4	2	7	6	4	3
September 19th	Wind direction . . .	NNE	NNE	NNE	NNE	NNE	NNE	NE	NNE	NNE	NE	ENE	ENE
	Velocity, miles per hour . .	5	4	2	3	4	3	4	3	6	5	7	5
September 20th	Wind direction . . .	SE	SE	SE	SE	ESE	ESE	ESE	ESE	ESE	ESE	ESE	SE
	Velocity, miles per hour . .	5	7	8	5	5	3	6	4	6	7	14	10

Date.	Times.	12 to 13.	13 to 14.	14 to 15.	15 to 16.	16 to 17.	17 to 18.	18 to 19.	19 to 20.	20 to 21.	21 to 22.	22 to 23.	23 to 24.
September 18th	Wind direction . . .	NNE	NNE	NE	ENE	ENE	ENE	Calm.	Calm.	E	SSE	ENE	NNE
	Velocity, miles per hour . .	3	4	5	5	2	1	0	0	1	6	8	4
September 19th	Wind direction . . .	E	E	E	SE	SE	SSE	SSE	SSE	SSE	SE	SE	SE
	Velocity, miles per hour . .	6	7	5	4	5	4	6	7	7	10	6	9
September 20th	Wind direction . . .	SE	SSE	SE	SE	SSE	SE	SE	SE	SE	SE	SE	SE
	Velocity, miles per hour . .	11	15	11	13	9	9	7	6	7	4	7	8

Rangoon is about 280 miles, in an east north-easterly direction, from that part of the Bay in which the cyclone was undoubtedly formed. It will be seen that, in the early part of the 18th, the wind at Rangoon was variable. Almost throughout the remainder of the

day, a steady north-easterly wind was blowing, showing a very distinct in-draught towards that part of the Bay, where the storm was probably beginning to form. On the following day, the 19th, these conditions continued to hold good, up till about midday; though the wind was becoming more easterly, and from 12 to 3 P.M. blew from the east, and then passed round to south-east; when, also, the wind velocity began to increase. It would therefore appear that the wind circulation, in connection with the storm, had not become sufficiently established, or sufficiently extensive to affect Rangoon, until the afternoon of the 19th. The cyclonic circulation having thus been fully formed, and the cyclone having begun to move away slowly, the velocity, at first, steadily increased at this station, till it attained a maximum of 14 to 15 miles an hour on the 20th; and then, as the storm passed away, returned to its normal amount, though the wind direction remained at south-east, showing an in-draught towards the storm, then advancing across the Bay. The Rangoon anemometric observations, thus, very clearly confirm the fact that the cyclone was in process of formation on the 18th September, and the early part of the 19th, and that by the afternoon and evening of that date it had fully formed; and that soon after its formation it began to retreat from that station.

The next station from which anemograms were received is Cuttack. The storm had of course fully formed, long before it reached this station; and indeed, before this, it had attained its maximum intensity, and was beginning to abate in strength. It was passing to the north of the station, and at 10 A.M. of the 22nd was about 45 miles to the north-east of it. The records of the anemograph at that station on September 21st, 22nd, and 23rd are given in the attached table:—

Date.	Times.	0 to 1.	1 to 2.	2 to 3.	3 to 4.	4 to 5.	5 to 6.	6 to 7.	7 to 8.	8 to 9.	9 to 10.	10 to 11.	11 to 12.
September, 21st.	Wind direction . .	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	Calm	NNE	NNW	Calm
	Velocity, miles per hour . .	0	0	0	0	0	0	0	0	0	2 1	1	0
September, 22nd.	Wind direction . .	Calm	WNW	Calm	Calm	Calm	Calm	WNW	SSW	WSW	SW	SW	SSW
	Velocity, miles per hour . .	0	1	0	0	0	0	7	15	22	32	37	31
September, 23rd.	Wind direction . .	SSW	SSW	SSW	S	Calm	Calm	Calm	SSE	SSE	SSE	SSE	SSE
	Velocity, miles per hour . .	5	3	3	2	0	0	0	1	1	1	3	6

Date.	Times.	12 to 13.	13 to 14.	14 to 15.	15 to 16.	16 to 17.	17 to 18.	18 to 19.	19 to 20.	20 to 21.	21 to 22.	22 to 23.	23 to 24.
September, 21st.	Wind direction . .	Calm	Calm	NNW	NNW	N	Calm	Calm	Calm	Calm	WNW	Calm	Calm
	Velocity, miles per hour . .	0	0	1	3	3	0	0	0	0	1	0	0
September, 22nd.	Wind direction . .	SSW	S	SSE	SSE	SSW	S	S	S	SSW	S	S	SSE
	Velocity, miles per hour . .	25	18	17	15	14	12	8	6	4	5	5	7
September, 23rd.	Wind direction . .	SSW	SSE	SSW	SSW	SSE	S	Calm	Calm	Calm	Calm	Calm	SSW
	Velocity, miles per hour . .	6	5	5	6	6	4	0	0	0	0	0	0

It is to be regretted that, as its general working has shown, the Casella's anemograph at Cuttack is not so sensitive as could be wished, but it appears to be quite sufficiently so to show distinctly any moderate wind velocity. Its insensitiveness to

light winds may perhaps to a certain extent detract from the value of the record above given, but the observations themselves show that the instrument was in fair working order, though perhaps with more friction than is desirable. The anemograms show a perfect calm, for 18 hours out of the 24, on the 21st September; and during the remaining six hours, a faint northerly wind of somewhat variable direction. Even for the six hours of appreciable movement, the average velocity was only one and a half miles an hour. The observations continued to show an almost perfect calm up till 6 o'clock on the 22nd; that is, though the cyclone was raging with great violence at False Point, which is only 60 miles to the east of Cuttack, and though the calm centre had actually nearly reached that port, there was no appreciable movement of the wind at Cuttack. At 6 A.M. it commenced to blow at W.N.W., changing subsequently through W.S.W. to S.W. and S.S.W. The greatest wind velocity recorded was during the three hours, from 9 A.M. to midday of the 22nd, during which the storm centre was travelling nearly to the north of the station. Between 9 and 10 A.M. the registered velocity was 32 miles; between 10 and 11, 37 miles; and between 11 and 12, 31 miles; and from this time it steadily and rapidly decreased, until, for several hours, from 4 A.M. on the 23rd, it was again calm at this station.

These observations, therefore, show that the storm was a small, but concentrated and most violent atmospheric disturbance, forcing and ploughing its way through an almost quiet atmosphere, giving little or no warning of its advance, and leaving little or no trace of its existence after its passage.

The results of the anemograph traces at Saugor Island, Calcutta, and Hazaribagh are less interesting, as those stations were further from the storm centre. The results of the anemograms at these three stations are given below. At Saugor Island the reduced hourly results are given for September 21st, 22nd, 23rd, and 24th. At Calcutta, for the three days, September 21st, 22nd, and 23rd, and at Hazaribagh for the 22nd, 23rd, and 24th:—

Hourly movements and directions of wind recorded at Saugor Island from 21st to 24th September 1885.

DATE.								DATE.							
21ST SEP- TEMBER 1885.								21ST SEP- TEMBER 1885.							
22ND SEP- TEMBER 1885.								22ND SEP- TEMBER 1885.							
23RD SEP- TEMBER 1885.								23RD SEP- TEMBER 1885.							
24TH SEP- TEMBER 1885.								24TH SEP- TEMBER 1885.							
Hours.	Miles.	Direction.	Miles.	Direction.	Miles.	Direction.	Miles.	Direction.	Hours.	Miles.	Direction.	Miles.	Direction.	Miles.	Direction.
Midnight to 1 A.M.	3	SSE	19	ENE	35	SSE	25	SSE	Noon to 1 P.M.	12	ENE	40	SE	30	SSE
1 to 2 "	3	SE	26	ENE	32	SSE	23	SSE	1 to 2 "	12	ENE	34	SE	28	SSE
2 to 3 "	7	E	23	E	32	SSE	23	SSE	2 to 3 "	19	ENE	36	SE	29	SSE
3 to 4 "	4	E	23	E	30	SSE	25	SSE	3 to 4 "	15	ENE	40	SSE	33	SSE
4 to 5 "	9	ENE	27	E	30	SSE	22	SSE	4 to 5 "	15	ENE	32	SSE	31	SSE
5 to 6 "	6	NE	33	E	31	SSE	24	SSE	5 to 6 "	19	E	33	SSE	30	SSE
6 to 7 "	7	NE	28	ESE	31	SSE	26	SSE	6 to 7 "	17	ENE	33	SSE	25	SSE
7 to 8 "	8	NE	29	ESE	32	SSE	21	S	7 to 8 "	12	ENE	32	SSE	28	SSE
8 to 9 "	23	NE	38	ESE	31	SSE	19	S	8 to 9 "	20	ENE	30	SSE	24	SSE
9 to 10 "	14	NE	32	ESE	30	SSE	21	S	9 to 10 "	18	ENE	29	SSE	30	SSE
10 to 11 "	11	ENE	38	ESE	30	SSE	20	SSE	10 to 11 "	20	ENE	31	SSE	30	SSE
11 to Noon.	10	E	32	SE	35	SSE	20	SSE	11 to Noon.	21	ENE	32	SSE	29	SSE

Hourly movements and directions of wind recorded at the Alipore Observatory from 21st to 23rd September 1885.

DAYS.		21ST SEPTEMBER 1885.		22ND SEPTEMBER 1885.		23RD SEPTEMBER 1885.		DAYS.		21ST SEPTEMBER 1885.		22ND SEPTEMBER 1885.		23RD SEPTEMBER 1885.	
Hours.		Miles.	Direction.	Miles.	Direction.	Miles.	Direction.	Hours.		Miles.	Direction.	Miles.	Direction.	Miles.	Direction.
Mid to 1 A.M.		0	C	7	ENE	10	SE by E	Noon to 1 P.M.		11	ENE	17	E	16	SSE
1 to 2 "		0	C	8	ENE	10	SE by E	1 to 2 "		9	ENE	17	E	14	SSE
2 to 3 "		0	C	9	ENE	11	SE	2 to 3 "		9	ENE	11	ESE	18	SSE
3 to 4 "		1	SSW	7	ENE	9	SE by E	3 to 4 "		7	NE by E	13	ESE	13	SSE
4 to 5 "		3	SSW	6	ENE	9	SE	4 to 5 "		8	NE by E	20	ESE	12	SSE
5 to 6 "		2	SSW	8	ENE	7	SE	5 to 6 "		9	E	14	ESE	10	SSE
6 to 7 "		4	SSW	7	ENE	9	SE	6 to 7 "		6	E by N	16	ESE	9	SSE
7 to 8 "		5	NE	11	ENE	10	SSE	7 to 8 "		8	ENE	13	ESE	9	SE
8 to 9 "		9	NE by E	18	ENE	11	SSE	8 to 9 "		8	ENE	10	ESE	9	SSE
9 to 10 "		10	NE	16	ENE	11	SSE	9 to 10 "		8	ENE	11	ESE	8	SE
10 to 11 "		11	NE by E	17	ESE	13	SSE	10 to 11 "		9	ENE	8	ESE	7	SE by S
11 to Noon		5	NE	15	E	12	SSE	11 to Mid.		11	ENE	8	ESE	8	SSE

Hourly movements and directions of wind recorded at Hazaribagh from the 22nd to 24th September.

Date.	Times.	0 to 1.	1 to 2.	2 to 3.	3 to 4.	4 to 5.	5 to 6.	6 to 7.	7 to 8.	8 to 9.	9 to 10.	10 to 11.	11 to 12.
September 22nd	Wind direction . . .	NNE	NNE	NE	NE	NNE	NE	NNE	NNE	NNE	NNE	NE	NE
	Velocity, miles per hour . .	6	3	6	8	8	10	18	13	13	23	23	23
September 23rd	Wind direction . . .	NNE	ENE	NE	ENE	E	E	E	E	E	ESE	SE	ESE
	Velocity, miles per hour . .	27	30	28	29	34	35	34	34	33	33	33	31
September 24th	Wind direction . . .	SE	SE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSW	SSW	WSW
	Velocity, miles per hour . .	19	17	14	11	13	11	9	9	8	8	6	5

Date.	Times.	12 to 13.	13 to 14.	14 to 15.	15 to 16.	16 to 17.	17 to 18.	18 to 19.	19 to 20.	20 to 21.	21 to 22.	22 to 23.	23 to 24.
September 22nd	Wind direction . . .	NNE	NNE	NNE	NNE	NNE	NE	E	NNE	ENE	NE	NE	ENE
	Velocity, miles per hour . .	26	24	26	26	32	27	19	37	35	34	27	27
September 23rd	Wind direction . . .	ESE	E	SE	SE	SE	SSE	SE	SE	SE	ESE	SE	SSE
	Velocity, miles per hour . .	22	22	20	19	20	19	19	18	18	21	18	18
September 24th	Wind direction . . .	W	W	W	W	NW	NNW	NNW	NNW	NNW	NNW	NNE	NE
	Velocity, miles per hour . .	8	8	10	9	11	10	7	4	3	3	4	4

A very brief examination of the Saugor Island register will show that the wind directions, at this station, began to feel the influence of the storm early on the morning of September 21st. Saugor Island being in a very exposed position, the wind movement is always comparatively high, and thus east-north-easterly winds of considerable velocity blew for the greater part of the 21st and until 2 A.M. of the 22nd, when the direction became easterly; and it remained in this direction until 6 A.M. of the same date. At this time, when the wind was easterly at Saugor Island, the storm centre was about south-south-west of that station. The wind then became east-south-easterly, from 6 to 11 A.M., and finally south-south-easterly for the remainder of the day, the 23rd, and the earlier part of the 24th. Strong winds blew continuously from about 6 A.M. of the 21st

and through the greater part of the 24th instant: the maximum velocity registered was 40 miles an hour. It will be here noticed that, at no time, was the wind direction tangential to the storm centre, but that it always showed a considerable indraught towards the centre.

The wind records of Calcutta for the 21st, 22nd, and 23rd September, show that the winds at this station were unaffected by the storm in the Bay, up till about 8 A.M. of the 21st. The wind then began to strengthen rapidly, and became north-easterly; in which direction it continued to blow until 9 A.M. of the 22nd; when it veered through east to east-south-east and south-east. Now Calcutta was never nearer than about 180 miles from the storm centre, and was therefore quite in the outer circles of the wind circulation. A comparison of the directions registered at Calcutta and shown in the above table, with the position of the storm centre from time to time, shows that the influence of the storm on the Calcutta wind directions was mainly that of causing indraught towards the advancing storm, rather than of any well-defined participation in a cyclonic circulation.

The storm centre appears to have passed about 60 or 70 miles to the south-west of Hazaribagh, at about 3 A.M., of the 23rd instant; and it was to the west, and passing to the north-west of the station at about 8 or 10 A.M. of the same day. The facts of the wind records of Hazaribagh may be summed up by saying, that a strong and fairly steady north-easterly wind was blowing from the forenoon of the 22nd up to about 5 P.M., when the centre bore due south of Hazaribagh. It then, for some time, became more easterly and somewhat variable on either side of north-east, and then settled down to a strong north-easterly gale during the whole time that the cyclone was travelling to the south-west of Hazaribagh, changing to a strong easterly gale when it was west of the station; and it was only when the centre had got well to the north of west that the wind directions at Hazaribagh became south-east. It is therefore clear from these autographic records that there was a very strong indraught towards the storm centre, and that for a considerable portion of the time, even when the storm centre was comparatively close to Hazaribagh, the winds were part of a well defined spiral system. At no time were their directions circular around the storm centre. In fact, for a large part of the time, they subtended an angle of less than 45° with the radius of the storm. If decisive proof of the direction of the winds in cyclones be really needed the above records of the five anemographs within the influence of the storm afford it most clearly, and show that the theory of the circular movement of winds in a cyclone which was advanced by Reid and Piddington, and has been supported by some later writers,¹ is utterly untenable. At considerable distances from the storm centre, the winds approach more to the radial direction of indraught towards the centre as advocated by Espy, than to any circular movement. As the centre of the storm is approached, the circulation appears to become more defined; but even just outside the storm centre there is no evidence to show that the direction is tangential.

Another point which comes out in the above anemographic records is that, though the wind directions in various parts of the storm are fairly steady and uniform in direction, yet there are considerable variations from time to time; the wind backing and veering slightly in different parts of the storm from causes which are not explicable.

¹ Still more strongly do they negative the strange conclusion advocated by M. Faye that cyclones are descending air columns.—*Ed.*

The velocities as recorded by the anemographs are not very large; about 37 to 40 miles an hour being the maximum at Hazaribagh, Cuttack, and Saugor Island, but, as pointed out previously, the Cuttack anemograph, which should have shown the highest rate of movement, is certainly not a sensitive one, and it is probable that the wind velocity was really much greater than there shown.

The above is only a very imperfect summary of the valuable results which can be obtained from the study of the wind directions recorded in this cyclone. It is however not intended to deal thoroughly with this portion of the subject here, and an attempt will be made in a subsequent paper to work out fully the relation between the position of the centre of the storm and the incurvation of the winds, and also sundry other points which are connected with this subject.

GENERAL REMARKS AS TO THE FORMATION OF THE STORM, AND DISCUSSION AS TO ITS BEARING ON CYCLONE THEORIES GENERALLY.

The foregoing history of the False Point cyclone shows that this storm is noteworthy from several points of view. The features which render its discussion peculiarly interesting, are, first, the rapidity of its formation; second, its smallness; third, its fierceness; fourth, the extraordinarily low barometric pressure registered during the storm, which is believed to be unprecedented; fifth, the destructive storm-wave accompanying it; sixth, the absence of any decided warning indications of the existence of so fierce a storm; seventh, the rapidity with which it abated in intensity after reaching the land; and, lastly, the fact that while the cyclone was in process of formation, the rainfall in Bengal was about equal to the normal for the time of the year, the fact generally observed being that rain is almost withheld from the land during the formation of an intense cyclone.

Generally speaking, the history of this storm supports the 'condensation' theory of the formation of cyclonic storms. This theory is accepted by most Indian Meteorologists, holding good in the case both of severe cyclones and of the smaller cyclonic storms of the rainy season. Its establishment in India is mainly due to the labours of Mr. J. Eliot, M.A., Meteorological Reporter to the Government of Bengal.

It is unnecessary here to give any detailed account of the "condensation theory," and of the manner in which it accounts for the phenomena observed in cyclones. It was worked out very ably by Mr. J. Eliot in his reports on the Backergunge and Madras cyclones, and in sundry reports on other cyclones and cyclonic storms, the accounts of which have been published from time to time in the *Indian Meteorological Memoirs*, and in other publications of the Indian Meteorological Department.

The following quotation from a recent paper by Mr. Eliot¹ will give a clear idea of the antecedent conditions, required by this theory, for the formation of a cyclone in the Bay of Bengal:—

"A storm may be briefly defined as a violent and extensive atmospheric disturbance. In the great majority of cases in India, if not in all, the motion is of a peculiar character, called cyclonic or vorticose. The air in the lower atmospheric strata is drawn inwards from all directions towards a central area, over which the air moves spirally upwards to some considerable height, and thence it

¹ Account of the south-west monsoon storm of the 8th to the 19th of October 1882 in the Bay of Bengal, by John Eliot, Esq., M.A., Meteorological Reporter to the Government of Bengal. *Indian Meteorological Memoirs*, Vol. II, p. 150.

flows outwards in a manner probably approximately the reverse of the lower motion of indraught. This is by no means a complete or satisfactory method of considering the totality of the phenomena which constitute a storm. During the existence of a cyclone, a vast amount of motion or kinetic energy is given to a large mass of air. This rapid accumulation of motion is usually the work of a few days, and it disappears again with equal rapidity. There is therefore a rapid conversion of some pre-existing form of energy into the kinetic energy of the atmosphere. A complete discussion of any known transformation of energy implies the consideration of two distinct questions—

"1st.—The source and character of the energy which admits of transformation.

"2nd.—The conditions under which the transformation is effected.

A storm, therefore, implies that, during its existence, some pre-existing form of energy is being rapidly converted into the kinetic energy of the moving mass of air, and this conversion can only take place under certain conditions. Various theories have been devised to account for the formation of cyclones, in the majority of which some one condition has been treated as if it were the sole or the effective cause. The phenomena of the present, as of many previous storms or cyclones in the Bay of Bengal, appear to me to indicate that it is the energy of heat, given out by the condensation of aqueous vapour, which is transformed into the kinetic energy of the air, and that the one important and effective condition for this transformation is more or less prolonged and concentrated rainfall over a definite area. This is only possible under certain antecedent conditions in the Bay of Bengal. Among the favourable circumstances, (which therefore constitute indications of the probable early occurrence of a cyclone), in the meteorology of the Bay of Bengal, appear to be the following, as they have been found to be present immediately before and during the generation of every storm, the history of which has been traced out by either Mr. Blanford or myself:—

"1st.—Uniformity of pressure over the greater part of the Bay, and the adjacent districts of Bengal, Orissa, &c., and usually over the whole of Northern India.

"2nd.—Almost entire absence of rainfall over North-Eastern India, and the coasts of the Bay; (more especially the northern coast).

"3rd.—The prevalence of fine clear weather, with light and variable winds in Bengal and Orissa; and in the case of the more severe cyclones, over the whole of Northern India.

"4th.—The prevalence of a strong southerly air current, laden with aqueous vapour, over the entrance and south of the Bay.

"5th.—Certain critical circumstances connected with aqueous vapour condensation, the conditions of which are not fully known, but which determine the commencement and continuance of rainfall over a limited but well-defined area, and over which the rainfall becomes more and more concentrated."

These conditions generally are only fully developed in India at the change of the monsoons, that is, in May and the earlier part of June and in October, and thus it is that, as a rule, violent cyclones are restricted to these periods, but when such conditions are partly present, the formation of cyclonic storms of the feeblar form becomes possible in the Bay of Bengal, particularly during the months June to September. Thus cyclonic storms vary greatly in magnitude, from the small and feeble cyclones of the rainy season, which are, generally, accompanied by moderate winds and a barometric depression rarely exceeding half an inch, to the less frequent, but large and violent cyclones of the transition periods, in which the wind force is excessive, and the barometric depression sometimes exceeds two inches. Again, while the latter class may or may not be accompanied by a storm-wave, which may submerge large tracts of country and cause disastrous loss of life and property, the smaller and feeblar cyclonic storms are never so accompanied. At sea, they may indeed cause some little damage near the centre, owing to the strength of the winds, and they may also cause floods over the land by the heaviness of the concomitant rainfall. But nothing approaching a storm-wave ever occurs in their advance.

According to the "condensation theory" the source of the enormous kinetic energy present in a cyclone is the energy given out by rainfall, and it is pointed out by Mr. Eliot in the paper above quoted, that—

"when rainfall occurs, the energy expended, or heat transformed during evaporation, is given back, and converted into some other form of energy. It is not changed into heat given to the rain drops themselves, and hence must be given up to the atmosphere from which the rain descends. The most important point in connection with this, is the rate at which this energy may be given up to the atmosphere, as compared with the rate at which energy is imparted by the direct action of the sun. This will be determined with sufficient exactness by comparing the direct evaporating power of the sun with the rate at which condensation may take place. The best experiments appear to prove that the sun, on a cloudless day, produces very little change of temperature in the air over the Bay of Bengal, and that its energy is probably not sufficient to evaporate more than a tenth of an inch of water. We shall, however, assume that the evaporation of half an inch of sea-water may be taken as an extreme rate of the direct action of the sun, and of the absorption of energy by the atmosphere due to this action. On the other hand, rainfall occurs occasionally over the land in India, and very probably over the sea during the storms, at the rate of 10 to 20 inches per diem for periods of 24 hours and upwards. We may take 10 inches as by no means an excessive estimate of the amount of rainfall in tropical storms over a considerable extent of the sea in one day. During such fall, twenty times as much aqueous vapour is converted into rain in 24 hours over a given area of sea surface, as the sun can reconvert into aqueous vapour in one day over an equal area.

"In other words, the disturbing effect, or the rate of absorption of energy by the atmosphere during rainfall, may be as much as 20 to 30 or even 40 times as great as the increase or absorption of energy due to the direct action of the sun. Hence the probability, if not certainty, that storms due to rainfall may be much larger and more intense and prolonged than storms caused by the direct heating of the sun or by relative differences of pressure and temperature."

The above explanation will, therefore, show, to a certain extent, the cause of the difference in magnitude and violence of cyclonic storms, at the transition periods, and during the rainy season. During the transition periods, for days and almost weeks together, the sun's rays, pouring down on the Bay of Bengal, cause an enormous amount of evaporation. The atmosphere thus becomes loaded with aqueous vapour, and with the continuance of such conditions, it arrives at a critical state, such that, under the influence of any exciting cause, at any one particular part of the Bay, torrential and very concentrated rainfall may occur.

On the other hand when, during the rains, these conditions only obtain very partially, and for only limited periods, or more correctly, when there is only a slackening off of the monsoon current blowing over Bengal, which partially brings about these conditions, the rainfall over the Bay must be less intense and probably more widespread than in the former case, and the cyclonic storms, thus generated, will be correspondingly more feeble. The character of the rainfall will exert a marked influence on the nature of the storm formed. A light and widespread rainfall probably does not produce any thing in the shape of a storm at all. Even moderate or very heavy rainfall, though widely diffused, will probably not produce a storm, unless some favourable condition, at present not well understood, is present, but when intense and concentrated rainfall occurs with other favouring conditions, the formation of a cyclonic storm is probable; and the more intense and more concentrated the rainfall, the more fierce is the storm likely to be, for the energy set free is in direct proportion to the heaviness and concentration of the rainfall.

Now the False Point cyclone was certainly one of those fierce storms that usually occur only at the transition periods, and it was accompanied by a very considerable storm-

wave. The first of the conditions laid down by Mr. Eliot, *vis.*, uniformity of pressure over the greater part of the Bay, and the adjacent districts of Bengal, Orissa, &c., and more or less over the whole of Northern India, has been shown in the detailed history of the storm to have existed for several days anterior to the generation of the storm. In respect of the second condition, the almost entire absence of rain over North-Eastern India and the coasts of the Bay (more especially the northern coast), the facts are only partially in accordance with the requirement. It has been shown that, though rain had ceased in Northern India, moderate amounts were still falling over the greater part of Bengal; and that for several days preceding the storm the fall on this province was almost equal to the normal amount for the season.

The third condition, *vis.*, the prevalence of fine clear weather, with light and variable winds in Bengal and Orissa, and in the case of more severe cyclones, over the whole of Northern India, was also, as has been shown in the previous part of this paper, fairly fulfilled in the present instance; except for occasional showers in Bengal, fine weather prevailed for many days previous to the storm; but it is true that this, as well as the second condition, were not so thoroughly fulfilled, as has been the case in other fierce cyclones. In the case of the fourth condition, the prevalence of a strong southerly air current laden with aqueous vapour over the entrance and south of the Bay, the early history of the storm very fully bears out this requirement; the ships' logs almost without exception testify to a rather strong monsoon current over the whole of the entrance and south of the Bay, and particularly in its south-east corner.

The fifth condition specifies certain critical circumstances connected with the condensation of aqueous vapour, which are not fully known, but which determine the commencement and continuance of rainfall over a limited but well defined area, over which the rainfall becomes more and more concentrated. In respect of this, it has been shown in the detailed history, that on the morning of the 18th September there was no sign of any cyclone having been formed in the Bay, but that in the place where the storm afterwards formed, pressure had slowly but very distinctly fallen during the previous 24 hours, and this area of falling pressure was surrounded on all sides by areas of increasing pressure.

The wind was light and unsteady, and the weather hot, sultry, and oppressive over this area as shown by the log of the *Governor Wilmot*. Again, at midnight of the 18th, the *Governor Wilmot* reports "rain, very overcast, and squally looking, with smooth water;" midnight to 4 A.M. of the 19th, "increasing breeze with rain; 4 A.M., constant rain and big sea; 8 A.M., very squally strong breeze, constant rain; forenoon, dirty rainy weather; noon, constant heavy rain, wind very unsteady, rain all time; 4 P.M., very heavy rain and increasing breeze; 8 P.M., whole gale." There was therefore, first, the slow reduction of pressure, and then the setting in of continuous rain, which, as time went on, became more and more concentrated. During this period, the cyclone was evidently in process of formation over this area, and by the 20th it was fully formed. During the 20th, the *Governor Wilmot* experienced "constant heavy rain," and from this time all the ships that were within the influence of the storm, and particularly those near the central track, in every case reported heavy rain, such expressions as "downpour of rain," &c., occurring in the various logs.

So far, then, as the detailed history of the storm affords evidence, the slight fall of the barometer, on the 18th, was restricted to the eastern part of the centre of the Bay,

to Diamond Island, &c. Such a fall would imply an upward movement of the atmosphere. This upward movement of a column of air which was almost saturated with moisture, as the air would be over the Bay of Bengal at that time, in obedience to well-known physical laws, would cause the condensation of the vapour as rain and a rapid reduction of temperature. In the conversion of vapour of water into rain drops, the heat which was previously "latent," or stored up in the water vapour, becomes sensible heat, which, as pointed out before in the extract from Mr. Eliot's report, will act directly on the air surrounding the drops; the air, thus being heated,¹ will be further expanded, and thus cause further ascensional motion and a consequent continuance and even intensification of the same conditions and phenomena. An ascending current of air having thus become established over this part of the Bay, it was fed from below by vapour-laden winds drawn in to the area of convective ascent; these also, taking part in the general ascensional movement.

Hence the conditions required by the "condensation theory" for the generation of a cyclone are actually known to have been present over the area, in which the cyclone was subsequently formed. On the other hand, other abnormal meteorological conditions, sometimes asserted to be the determining cause of cyclones, such as, opposite parallel currents, are shown by the ships' logs not to have been present.

The rainfall, which was the cause of the cyclone, is shown to have been very local and heavy, and a period of between 24 and 48 hours was sufficient to generate the storm. At first, it appears to have been comparatively feeble, but it rapidly grew in strength, and attained its maximum force, just before reaching the land, on the morning of September 22nd. The rapidity of its formation is probably accounted for by the exceptionally heavy rainfall, its smallness by the very local nature of the conditions which caused the rainfall at the commencement of the storm, for the slight fall of pressure and the heavy rainfall were at first restricted to the area of its formation. The fierceness of the storm is proved by the exceptionally low barometric pressure which, as before stated, was lower than any previously on record, either in Indian seas or elsewhere. The smallness of the vortex, and its great rapidity of advance, explain why so little warning was given of its approach.

The storm followed a north-westerly track, which is common in the case of the smaller cyclonic storms during the rainy season, as has been shown by Mr. J. Eliot in his paper² in Vol. II of the *Indian Meteorological Memoirs*. It appears to have ploughed its way through an atmosphere which had previously been almost quiescent; but no certain indication of the cause of the direction of its advance can be obtained. Again, in respect to the rather unusual rapidity of advance of the storm which averaged 13 miles an hour, there is no evidence to show what caused the movement to be more rapid than usual.

The next point of interest is the comparative rapidity with which the storm abated after it had reached the land. In this connection, some suggestions as to the nature and classification of cyclonic storms, made by Mr. J. Eliot, are of great interest. In the

¹ I am quite unable to coincide with the views expressed in this passage, which appear to postulate as simultaneous two contradictory processes. I can only understand the emission of latent heat as *retarding* that fall of temperature which causes condensation, not as heating and expanding the cooling air.—*Ed.*

² Account of the South-West Monsoon Storms generated in the Bay of Bengal during the years 1877 to 1881, by John Eliot, M.A. *Indian Meteorological Memoirs*, Vol. II, p. 217.

paper already quoted, he calls attention to one very striking difference between the extensive cyclones of the transition periods, and the smaller cyclonic storms of the rains. The large cyclones, notwithstanding the greater extent and intensity of the disturbance, have usually much shorter lives than the smaller cyclonic storms. Hills of only moderate elevation appear to oppose an effective and insuperable barrier to the progress of large cyclones, in some cases causing them to recurve, in others to break up and almost disappear within the space of a few hours. On the other hand, these same hills have, in many instances, hardly any effect on the smaller cyclonic storms of the rains, and such storms have been known frequently to pass almost entirely across the head of the peninsula; in some instances, even increasing in strength, in their progress over the land. Mr. Eliot says :—

“Such a difference of vitality of the two classes of cyclonic storms of the Bay is evidently of great importance, and can only be due to some marked difference in their formation or character. There is only one feature in which it appears to me that they may differ, which will explain these facts.

“The chief and effective cause of cyclones is the rapid condensation of aqueous vapour over a limited central area. It is evident that the condensation and its accompanying transfer of energy to the atmosphere may occur at different levels, according to the varying meteorological conditions. Thus at the transition periods, when the accumulation of vapour is largely due to local evaporation, and hence takes place mainly in the lower atmospheric strata, it is probable, if not almost certain, that the condensation will occur at a comparatively low level, and hence the cyclonic motion of indraught below and outdraught above will only extend to a moderate elevation, and the whole cyclonic circulation will be confined within limits from the sea-level upwards, not much greater than the elevation of the hills of Eastern Bengal, Orissa, &c. If this be the case, these hills will form a complete and effective barrier to the progress of such a cyclonic motion.

“On the other hand, during the rains, aqueous vapour condensation is mainly due to slight initial changes in an atmosphere, almost saturated up to very considerable heights. Hence, it is probable, not only that the condensation will, in this case, occur at a much greater elevation than in the preceding, but that it may extend through a greater vertical depth of atmosphere and the whole motion through a much greater height, and the main body of the indraught, instead of occurring near the earth's surface, may in consequence take place a considerable height above it. Cyclonic motion extending to a height of 10,000 feet, for example, and in which the aqueous vapour condensation occurs at an elevation exceeding 5,000 feet, may be accompanied by, and give rise to, comparatively feeble motion near the earth's surface, and may advance almost unaffected, and certainly unbroken, over hills 2,000 and 3,000 feet high, such as the Orissa hills or the Eastern Ghâts. No further consideration appears to be necessary to show that the different phenomena may be explained by the assumption of cyclones of low elevation, and cyclones of high elevation. The one class, of course, pass into the other by insensible gradations. There are, however, clearly-marked differences between the two types of cyclones which originate in the Bay of Bengal, in connection with the south-west monsoon.”

In the detailed history of the storm now in question, it has been seen that it was of enormous fierceness at sea, and particularly as it approached the land over the coast line the gale blew with tremendous force, and along the sea-face did a very large amount of damage.¹ But the extracts previously quoted from the report of the Commissioner of Orissa, and the reports from the Observatory at Cuttack, show that, at the inland stations in Orissa, the amount of damage done was very much less than that near the sea-face. After leaving the plains and the sea-face of Orissa, the storm passed into a somewhat hilly country, *viz.*, the low hills to the west of Orissa and thence into Chutia Nagpur,

¹ This was mainly the work of the storm wave.—*Ed.*

which is elevated ground with numerous and sometimes high hills; and from Chutia Nagpur not a single report of any considerable damage has been received, nor any which show more than that, during the passing of the storm, moderately strong winds blew over the province. It seems, therefore, that nothing like a fierce cyclonic storm passed over Chutia Nagpur. Again, in Behar, it is recorded only in a single newspaper report, that some damage was done by what was apparently an offshoot of the main body of the storm, which blew down many trees, &c.; but the damage was essentially local. It may be therefore inferred that this fierce cyclone became comparatively feeble and destructive after passing through or over the low hills to the west of Orissa, and to the south of Chutia Nagpur. This would indicate that the False Point cyclone was one in which the main force of the storm occurred at a comparatively low level, implying that little, if any, vapour condensation was taking place in the upper levels of the atmosphere.

One report received in the Bengal Meteorological Office is extremely valuable in connection with this point. The report was sent in by Mr. S. R. Elson of the Bengal Pilot Service, and one of the most experienced members of that service, particularly in the matter of cyclones, to which he has devoted much attention for many years. Therefore in the matter of cyclones and cyclonic storms Mr. Elson's observations can be thoroughly trusted. Describing the weather at the Sandheads, a station within some 50 or 60 miles of the path of the storm centre, and certainly within the outer gale circle, Mr. Elson writes:—

"22nd September, at 3 A.M., wind 6·7 east-south-east, observe distant desultory flashes of lightning right in the wind's eye, or east-south-east, a token that the breeze is not yet finished as I had hoped, when we had the thunder yesterday, and when the upper scuds were showing a tendency of the surface wind to veer round to the southward. A south-east swell showing in heavy rollers now and then.

"There are breaks in the sky now and then, through which the stars come out here and there in the zenith.

"7 A.M. A heavy cross-sea running; the brig soon parted her cable as she rose to one of the steep crests, set small sail and stood down with vessel's head about south-west by south, but in the westward set of 5 knots that is running, only made about a course of west-south-west good, the wind having veered to south-east by south by 8 A.M.

"2 P.M. Wind south by east, force 6; a heavy southerly swell running. Suppose we are on the north end of Pilot's Ridge.

"All this day, say from 9 A.M. to 2 P.M., the sky was comparatively clear of cloud. The surface breeze and low driving scuds being confined to a very thin stratum. Now and then smoke-like scuds would stretch up from the surface right across the wind direction, as I have observed in most cyclonic storms, more especially in those small whirls of the rainy season: the current immediately above the surface coming from about 4 points right of the wind direction. But most remarkable, there seemed to be perfect stillness of the air strata, but a small height above the hurricane wind, so far as any lateral direction was concerned; for tall tufts, or 'thunder-heads,' as they have been termed, rose here and there, straight up towards the lofty cirro-cumulus, having level vapour planes to each, undisturbed by the indraughted surface winds of the meteor. These thunder-heads, or tufts, were mostly to the south-east. We had but very little rain after 9 A.M., when the wind had gone to the southward of south-east.

"The sky looked very wild to the westward late in the day, due of course to the receding cyclone.

"On the whole, as the barometer did not fall below 29·30 with us, although it appears we could not have been over 50 miles off the storm centre; and considering the comparatively fine weather appearances we were having at the time, I was very much surprised to learn that such a severe storm had raged so near us on the 22nd instant, and where the barometer was said to have fallen so low as 27·10", giving a steeper gradient than I suppose has ever been recorded.

"I have never known a severe cyclone give such little warning as the one in question gave at the Hooghly Pilot Station, either with respect to the length of time, that the usual and precursory north-east wind blew, the westward set of the sea, the south-east swell, or the sky tokens. The whole of these premonitory signs were of but such short-duration before we had the change of weather, that only an ordinary stormy whirl of the rainy season was or could have been anticipated.

"(Sd.) S. R. ELSON."

Mr. Elson's observations with reference to the movement of the clouds are most valuable, and seem to show clearly that the upper strata of the atmosphere were not to any great extent agitated by the storm. His observations on this point are distinct, for he writes "the surface breeze and low driving scuds being confined to a very thin stratum." "Again there seemed to be perfect stillness of the air strata, but a small height above the hurricane wind, so far as any lateral direction was concerned, for tall tufts undisturbed by the indraughted surface winds of the meteor rose here and there straight up towards the lofty cirro-cumulus," &c. This statement seems to preclude the idea of there being either strong wind or rainfall in the upper strata and to prove that the storm with its violent motion was entirely confined to the lower strata of the atmosphere. Such being the case, the rapidity of its destruction by contact with the low hills of Orissa is at once explained.

APPENDIX.

Since Mr. Pedler's report was completed, a report on the floods and cyclone in Bengal in 1885, prepared in Bengal Department of Public Works, has been received. The map illustrating the flooded area north of False Point, which illustrates this report, is reproduced on a reduced scale on Plate VIII. The following is an extract from the Superintending Engineer's Report accompanying the chart:—

"The tract of country inundated by the storm-wave is shown on the accompanying map. I visited the place within 48 hours of the storm, and carefully collected whatever information could be obtained as to the inundation. It is nevertheless extremely difficult to reconcile these statements and condense them into anything like a clear account of the nature of the wave for the purposes of the report. The force of the gale, in the early morning, was felt at False Point from the east, and this had the effect of raising the sea about 4 to 5 feet above H. W. Spring tide-level.

"Directly after the passage of the centre of the storm, the water rose at False Point Light-house to 14·6 feet above M. S. L., and at the Government buildings at Jumbo to 21 feet, and at False Point station to 22 feet above M. S. L. At Taldunda, about 9 miles from False Point on the Mahanuddy, the gauge registered 10·90 feet above M. S. L. H. W. S. L. may be taken at 4 feet above M. S. L. at False Point. At Jumbo, the storm-wave is said to have risen to 10 feet above the coping of the tail lock of the Kendrapara canal, 21 feet above M. S. L. The slopes of the canal banks were not much cut about, and showed no signs of the passage of the storm-wave, although the banks were strewn with dead cattle, and the adjacent lands covered with salt water. The centre of the storm passed through False Point harbour, and took a north-westerly direction inland through Pattamoondi: the sea-waves followed a northerly direction along the coast.

"No damage is reported south of the Mahanuddy, and the tract inundated by the wave lies entirely between the Mahanuddy and Brahmini rivers. The effect of the wave was, in this length of the coast of the Bay of Bengal, considerably influenced by the range of low-lying sand hills, more or less continuous, which extend from the mouth of the Brahmini to Kuldeep, a distance of 15 miles. The inundated tract may be defined as generally a flat plain, at or below mean tide-level from + 4 to + 5 above M. S. L., intersected by a network of salt water tidal creeks.

"The depth of inundation, or the height of the storm-wave, with reference to the country-level, appeared to decrease from the shore inland, and to be gradually less from the village of Rajnugger up to the Brahmini river, where it was 4 to 5 feet above H. W. S. L. The facts observed would be best accounted for by supposing the storm-wave to be a solid and well-defined mass of water, of the nature of a water-spout, travelling about half an hour behind the centre of the storm. The duration of the wave appears to have been less than an hour. Some accounts state that it lasted only half an hour, and that a succession of waves occurred in this time: it then rapidly subsided.

"The result of this terrible calamity may be briefly summed up as follows:

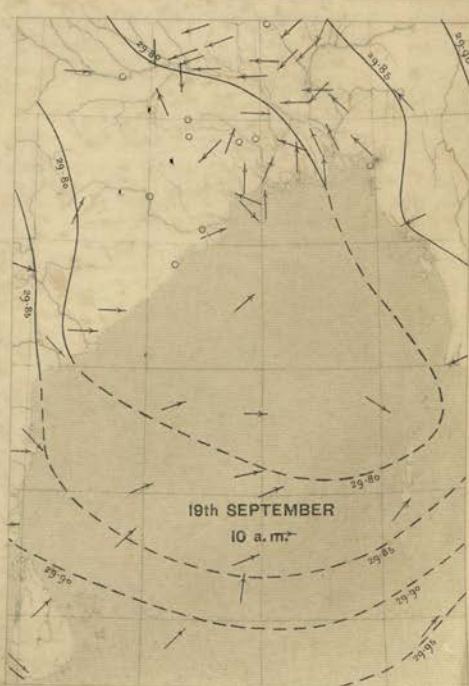
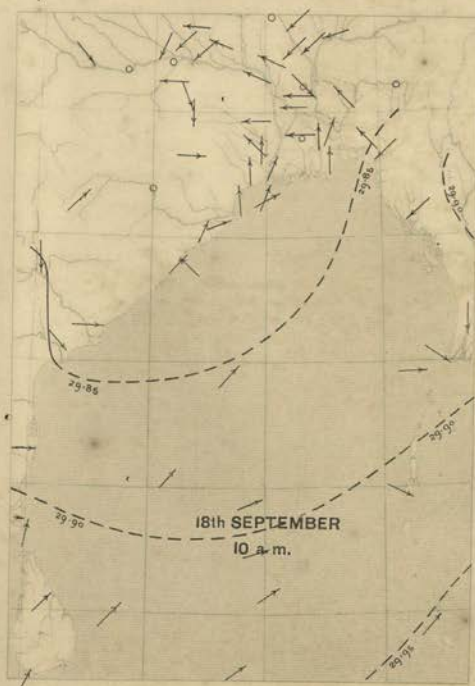
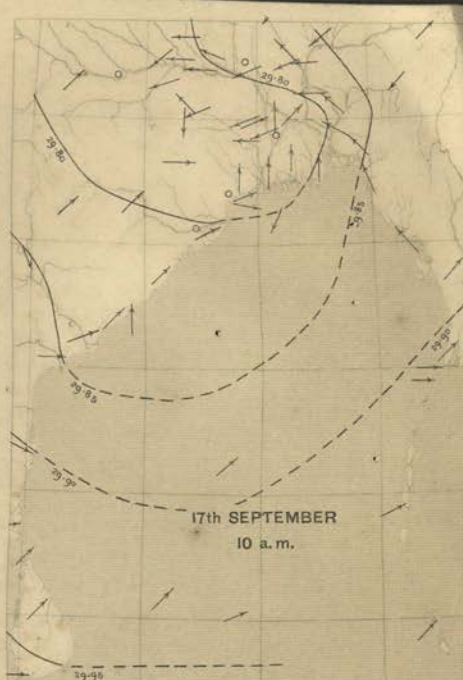
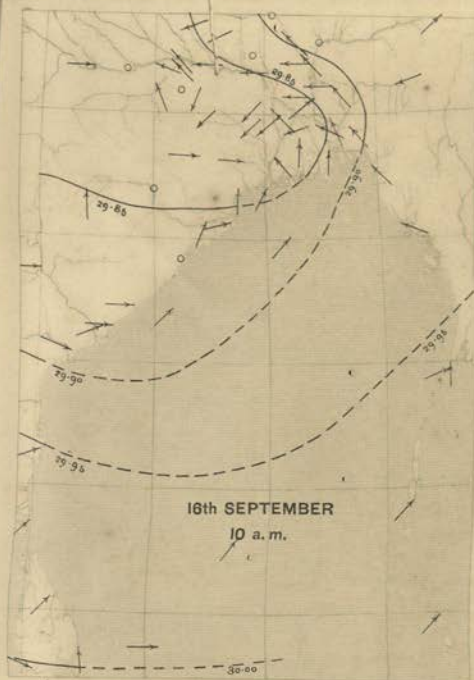
"Two thousand households were entirely swept away, representing a loss of from six to ten thousand souls, according as the estimate is taken at three to five persons in each household. Crops valued at ten lakhs of rupees were irretrievably damaged by salt water and lost.

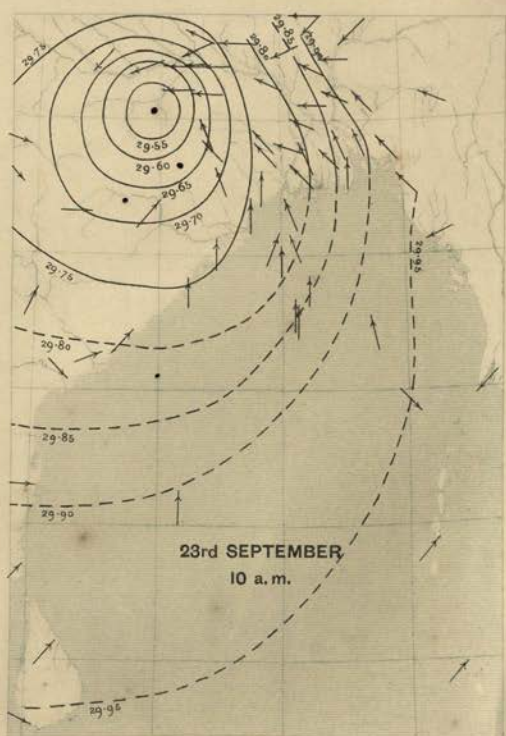
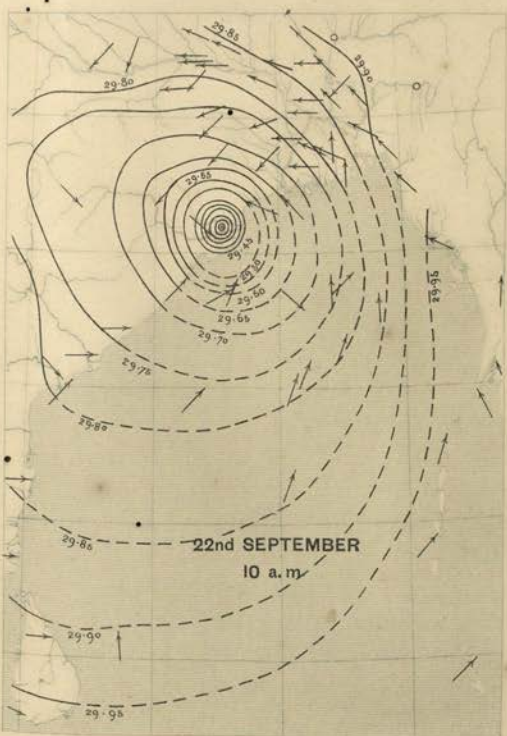
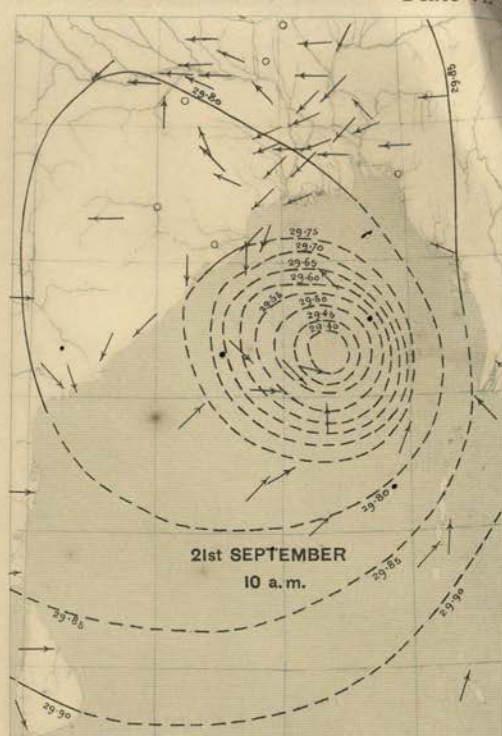
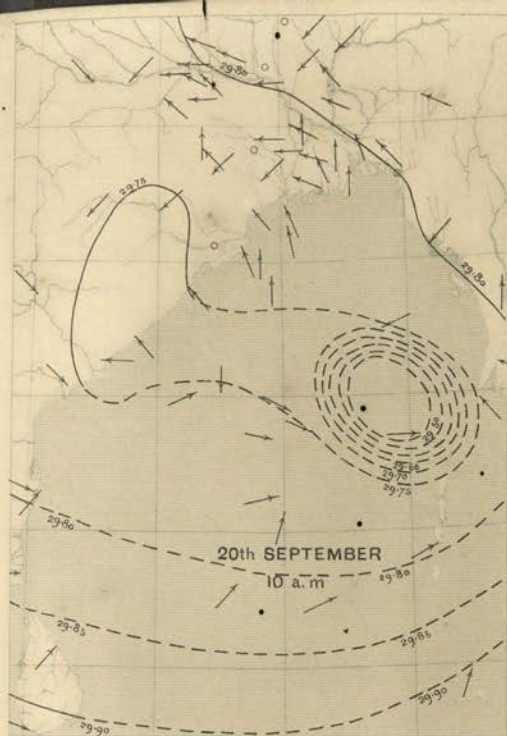
"The wells and tanks for drinking-water were made unfit for use: about 60,000 acres of land were rendered unfit for cultivation for two or three years to come by salt water, and the waves have been followed by an outbreak of fever of a virulent type. Considering that this report is written for experienced officials, it is perhaps not necessary to emphasize the mute eloquence of facts such as these by dwelling on the unspeakable horrors which accompanied this frightful catastrophe.

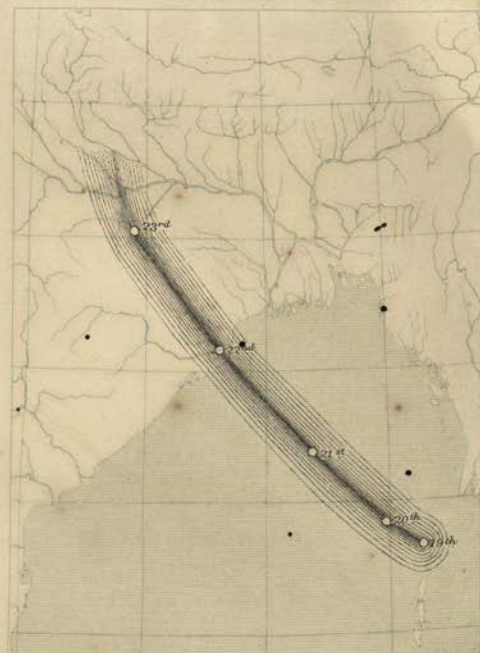
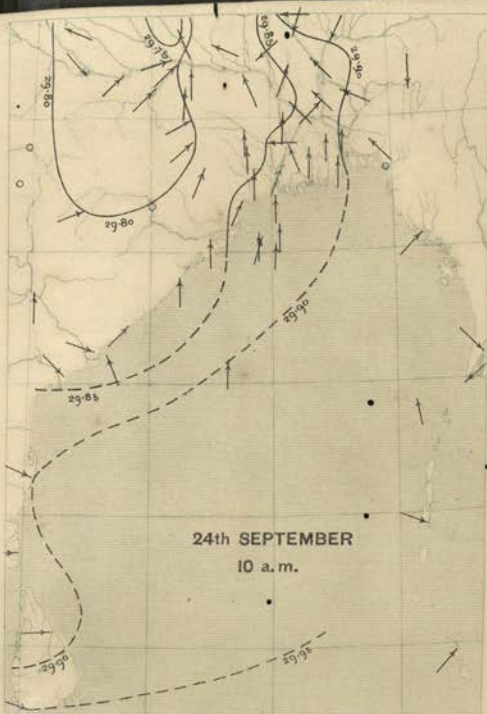
"The liability of the low country on the Orissa coast to such calamities is well defined by past experience. In 1820-21, 1839-41,* and 1848† similar storm-waves devastated the Kanika estate, and almost entirely depopulated it. Independent of storm-waves, which have made a clear breach over the country, high tides are of frequent occurrence, which find their way into the country through the creeks, destroying crops, making all the drinking-water salt, and throwing the fields out of cultivation for two to three years after. It is perhaps no exaggeration to say that 30,000 souls have been drowned by these storm-waves in the course of the last forty years. The miserable condition of the people, the sparse population, and low rents, compared with neighbouring districts, are a necessary consequence of this insecurity of life and property."

* 31st Oct. 1831, Blanford Cyc. Cat., XXX.

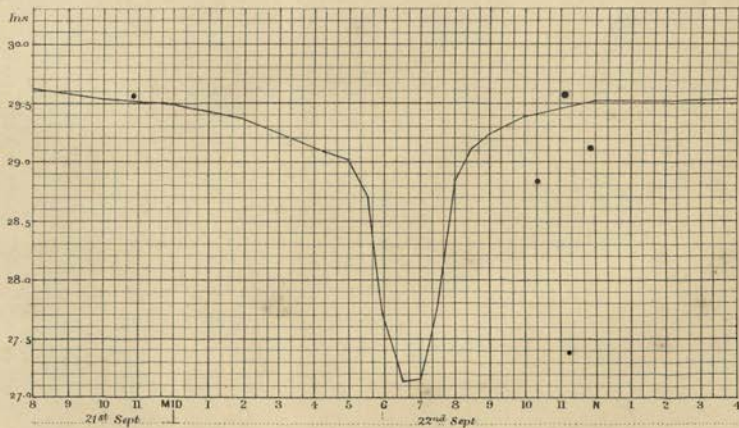
† 14th Oct. 1848 " " " LIX.





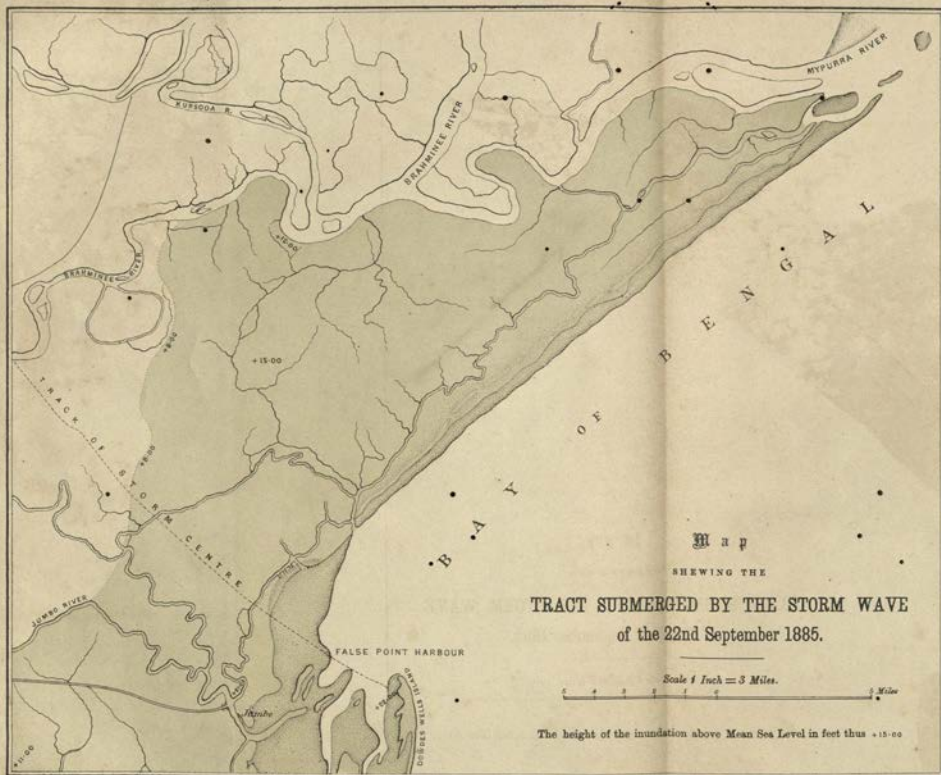


PATH OF FALSE POINT CYCLONE
from September 19th to 24th.



Progress of Cyclone nearly 13 Miles per hour.

DIAGRAM OF REDUCED BAROMETRIC PRESSURE
AT FALSE POINT OBSERVATORY DURING PASSAGE OF CYCLONE.



ERRATA.

Page 150, line 9, delete the thick space mark before A_1 ,

Page 150, line 18, for the second A_2 read A_2 ,

• • and wherever the products αx , $\alpha_1 x$, $\alpha_2 x$, appear in the formulæ *insert*
before them the negative sign.

Page 152, last line, for κ [Greek] read K .

Page 157, line 23, for 1 and 3 read 7 and 9.

Page 160, line 3 from bottom, for 16, 17, 18 and 19, read 6, 7, 8 and 9.

V.—On the Ground Temperature Observations made at the Old Observatory, Allahabad;
by S. A. HILL, B.Sc., Meteorological Reporter to Government, North-Western
Provinces and Oudh.

In the year 1880, the temporary Observatory at Allahabad, where the meteorological observations were made before the erection of the present building, opened in 1885, was supplied from the Calcutta Meteorological Office with two thermometers, prepared for taking the temperature at depths of one foot and 3 feet below the surface of the ground. They were Casella standards, mounted according to what, I believe, is known as Lamont's system; that is to say, having part of the lower end of the wooden frame removed, and the bulb covered with a pointed copper shoe, which rests on the ground at the bottom of a wooden tube; while the top of the tube projects about eight or nine inches above the ground and is covered by a cap. The thermometers, as turned out by the maker, being about 20 inches long, no other alteration, except the addition of a loop of stout wire at the top to serve as a handle, had to be made to the instrument intended to take the temperature at a depth of 1 foot; but the 3-foot thermometer, with its frame, was let into one side of a stout wooden rod, $3\frac{1}{2}$ feet long, square in section and nearly fitting the tube; and by grasping the upper end of this rod, which was turned to a convenient shape, the instrument could be withdrawn for inspection. The tops of the tubes were at first covered with caps of tin-plate; but after about a twelvemonth, these were discontinued, on account of the facility with which heat passed through them, and wooden caps were substituted. To avoid the ravages of white-ants, the tubes, before being put down, were coated inside and out with coal tar.

In order to take the temperature of the surface, a similar thermometer was prepared, by cutting away the lower part of the wooden frame so as to expose the bulb, and it was then inserted upright in the soil, in such a way that the bulb, (in this case unprotected by a conducting shoe of copper,) was just covered. As the length of the bulb of this instrument was about an inch, the temperatures recorded by its means were strictly those pertaining to a layer half an inch below the surface.

Before being put down, the thermometers were carefully verified by comparison with a *Kew* standard; and after removal they were re-verified, the corrections for index error being found unchanged. These corrections were the following:—

	Number.	Correction at 80°
Half-inch	20,931 Casella	+ 0.3°
One-foot	23,785 "	- 0.3
Three-foot	24,312 "	- 0.2

A general description of the surroundings of the Observatory is given at page 312, Volume I, of these *Memoirs*. The soil is a sandy loam, belonging to what is known as the high or old alluvium of the Ganges (*banghar*). In dry, hot weather it becomes almost as hard as brick. It contains, about 18 inches or 2 feet below the surface, a layer of small nodules of *kankar* (nodular concretionary limestone). In putting down the tubes for the instruments, a small sloping trench was dug to a depth of 3 feet at the deeper end, and one corner of this was dressed square, with sides perfectly vertical. In this corner of the trench the 3-foot tube was planted and the soil carefully filled in and packed tightly

against it. Some distance along the trench, a portion of the undisturbed bottom was levelled at a depth of one foot, and the side of the trench at this place was cut truly vertical. Against this, the 1-foot tube was placed and the soil firmly packed about it, the rest of the trench being then filled up level with the surface. Finally, the surface instrument was set upright, with the bulb just covered by soil, and the scale facing south; the frame being fastened to a short stake driven into the ground behind it. Only in the early morning or late afternoon therefore, could the shadow of the frame and its supporting stake fall upon the soil around the bulb of this instrument; whilst the bulbs of the sunken thermometers were surrounded below and on one side, at least, by undisturbed soil. The instruments were enclosed within a small bamboo paling, which contained also the radiation thermometers and the rain gauge.

The thermometers were installed and the observations commenced at the beginning of May 1880. The observations continued until the end of August 1886, after which the thermometers were returned to store at the new Observatory, to which all the other meteorological instruments had been removed. For 20 months prior to their cessation, however, a parallel series of observations was carried on at the new Observatory, with the object of utilizing these now discussed, as well as future observations, in the investigation of ground temperature variations of long period.

DIURNAL VARIATION.

The regular observations were made every day at 4, 10, 16 and 22 hours, down to the end of November 1885; after which, only three observations were made daily, at 7, 10 and 16 hours. All the observations have been reduced to daily means, by the application of corrections, derived from an hourly series made in 1881—2, on four days in each month; the hourly values being afterwards adjusted by inserting, instead of those actually found for 4, 10, 16 and 22 hours, the means of the whole series of $5\frac{1}{2}$ years' observations at these hours, and applying proportionate corrections for the intervening hours. The corrected hourly means are given in Tables I, II and III.

TABLE I.—*Diurnal Variation of ground-temperature at a depth of half an inch.*

Hour.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
Midnight	56.6	61.4	72.7	83.2	87.5	89.9	84.3	84.4	83.3	75.7	64.3	58.0	74.9
1	55.6	60.2	71.4	81.6	86.0	89.2	83.9	83.8	82.6	75.1	63.1	55.3	74.0
2	55.0	59.0	70.3	80.2	85.2	88.4	83.6	83.3	82.0	74.5	62.1	54.5	73.2
3	54.6	58.2	69.2	79.0	84.1	87.6	83.2	82.8	81.3	73.8	61.3	53.8	72.4
4	53.7	57.2	68.2	77.8	83.4	87.0	82.7	82.5	81.0	73.1	60.7	53.2	71.7
5	52.9	56.3	67.2	76.6	82.7	86.9	82.4	82.3	80.5	72.9	60.3	52.6	71.1
6	52.2	55.3	66.3	76.3	82.5	86.8	83.1	82.2	80.3	72.5	59.9	52.0	70.8
7	52.0	54.8	67.0	78.5	83.4	89.6	84.0	83.4	80.3	72.8	59.8	51.8	71.5
8	55.1	58.4	72.9	85.5	90.8	93.8	85.3	84.8	83.5	76.1	63.2	54.4	75.3
9	60.5	64.9	80.8	96.0	100.6	97.6	86.9	86.5	87.5	81.9	69.5	59.6	81.0

TABLE I.—*Diurnal Variation of ground-temperature at a depth of half an inch—continued.*

Hour.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
10	66.5	72.2	87.5	101.7	107.4	101.5	89.2	88.5	90.7	87.9	76.0	66.5	86.3
11	71.5	77.1	92.2	108.2	110.8	101.9	90.7	90.1	93.5	91.2	80.7	72.1	90.0
12	74.9	80.5	95.1	112.5	113.0	102.5	91.9	91.5	95.3	92.9	83.4	75.8	92.5
13	76.5	82.5	96.9	113.6	114.5	103.7	92.5	92.3	96.2	93.4	84.7	77.5	93.7
14	77.0	83.1	97.1	111.8	113.8	104.2	92.2	92.6	96.1	92.6	84.7	77.8	93.6
15	76.9	82.7	96.5	109.3	112.4	103.8	91.7	92.3	94.1	91.5	83.6	76.9	92.6
16	75.9	81.6	95.0	106.6	110.1	103.2	90.8	91.2	92.5	89.5	82.1	75.0	91.1
17	72.7	78.5	92.3	102.9	106.8	101.4	90.1	89.4	90.9	87.1	78.7	71.3	88.5
18	69.2	74.9	88.2	98.4	102.6	99.3	89.4	88.7	88.6	84.1	74.7	67.2	85.4
19	66.1	71.3	84.4	94.2	98.0	97.2	88.1	87.8	86.7	81.8	71.9	64.0	82.6
20	63.5	68.5	81.1	90.7	94.7	95.1	86.8	87.0	85.4	80.0	69.9	61.5	80.4
21	61.2	66.0	78.4	88.1	92.4	93.3	85.7	86.1	85.3	78.7	67.9	59.5	78.6
22	59.2	63.8	76.1	86.0	90.8	91.7	85.1	85.1	84.5	77.4	66.0	57.7	77.0
23	57.9	62.5	74.4	84.6	89.2	90.8	84.8	84.7	83.9	76.8	65.0	56.8	76.0
Mean	63.22	67.95	80.88	92.64	96.80	95.27	87.02	86.80	86.92	81.39	70.56	62.62	81.01
Range	25.0	28.3	30.8	30.3	32.0	17.4	10.1	10.4	15.9	20.9	24.9	26.8	22.9

TABLE II.—*Diurnal Variation of ground-temperature at 1 foot depth.*

Hour.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
Midnight	65.82	69.34	79.68	89.30	94.60	94.69	88.21	87.29	87.52	83.04	73.86	66.14	81.62
1	65.57	69.11	79.33	88.97	94.36	94.55	88.05	87.17	87.39	82.94	73.60	66.00	81.42
2	65.34	68.83	79.02	88.69	94.12	94.39	87.90	87.11	87.26	82.78	73.34	65.83	81.22
3	65.16	68.49	78.70	88.31	93.88	94.23	87.74	87.04	87.13	82.62	73.17	65.61	81.01
4	64.82	68.20	78.38	87.94	93.55	94.07	87.58	86.97	87.00	82.47	73.00	65.38	80.78
5	64.58	67.95	78.23	87.74	93.26	93.83	87.41	86.90	86.93	82.32	72.90	65.22	80.61
6	64.36	67.69	78.07	87.52	93.13	93.69	87.33	86.83	86.87	82.18	72.81	65.03	80.46
7	64.29	67.54	77.92	87.41	93.00	93.59	87.26	86.76	86.80	82.06	72.73	64.83	80.35
8	64.21	67.43	77.78	87.30	92.88	93.49	87.19	86.69	86.74	81.95	72.66	64.77	80.26
9	64.13	67.35	77.63	87.18	92.76	93.39	87.12	86.61	86.67	81.88	72.60	64.70	80.17
10	64.06	67.30	77.48	87.08	92.68	93.30	87.05	86.53	86.60	81.83	72.55	64.64	80.09
11	64.03	67.29	77.46	87.04	92.70	93.23	87.04	86.49	86.57	81.78	72.61	64.63	80.07
12	64.01	67.33	77.45	87.13	92.77	93.28	87.04	86.52	86.57	81.77	72.71	64.68	80.11

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TABLE II.—*Diurnal Variation of ground-temperature at 1 foot depth—continued.*

Hour.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
13	64°08	67°42	77°43	87°23	92°89	93°47	87°11	86°55	86°63	81°83	72°84	64°80	80°19
14	64°19	67°59	77°67	87°49	93°19	93°67	87°23	86°68	86°78	81°98	73°00	65°02	80°37
15	64°40	67°88	78°01	87°84	93°52	93°90	87°38	86°80	86°96	82°09	73°23	65°27	80°61
16	64°80	68°24	78°46	88°26	93°80	94°18	87°55	86°93	87°22	82°28	73°52	65°56	80°90
17	65°17	68°68	78°93	88°60	94°20	94°33	87°77	87°10	87°66	82°60	73°79	65°87	81°23
18	65°57	69°09	79°39	88°98	94°55	94°43	87°96	87°26	87°80	82°90	73°99	66°19	81°51
19	65°86	69°44	79°82	89°36	94°80	94°49	88°12	87°38	87°98	83°15	74°10	66°43	81°74
20	66°06	69°69	80°08	89°57	94°92	94°57	88°22	87°46	88°00	83°30	74°14	66°52	81°88
21	66°13	69°78	80°15	89°72	95°01	94°72	88°33	87°50	87°97	83°37	74°14	66°54	81°95
22	66°16	69°74	80°14	89°68	94°97	94°90	88°43	87°52	87°78	83°33	74°13	66°50	81°94
23	65°99	69°47	79°91	89°48	94°82	94°82	88°35	87°41	87°65	83°17	74°03	66°33	81°79
Mean	64°95	68°37	78°63	88°24	93°77	94°05	87°64	86°98	87°19	82°48	73°31	65°52	80°93
Range	2°15	2°49	2°72	2°68	2°33	1°67	1°39	1°03	1°43	1°60	1°59	1°91	1°88

TABLE III.—*Diurnal Variation of ground-temperature at 3 feet depth.*

Hour.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
Midnight	69°58	70°67	76°98	84°19	89°18	91°66	87°99	86°94	86°99	84°57	78°27	71°63	81°55
1	69°55	70°62	76°93	84°15	89°15	91°65	87°99	86°93	86°98	84°56	78°26	71°60	81°53
2	69°53	70°59	76°88	84°10	89°11	91°64	87°98	86°92	86°98	84°56	78°25	71°58	81°51
3	69°49	70°55	76°83	84°05	89°10	91°63	87°98	86°91	86°97	84°55	78°24	71°56	81°49
4	69°48	70°52	76°78	84°00	89°10	91°62	87°98	86°90	86°97	84°55	78°23	71°54	81°47
5	69°46	70°50	76°76	83°99	89°10	91°61	87°98	86°87	86°96	84°53	78°20	71°51	81°46
6	69°44	70°49	76°75	84°00	89°09	91°60	87°98	86°88	86°96	84°49	78°17	71°50	81°45
7	69°41	70°47	76°73	84°00	89°08	91°59	87°98	86°89	86°95	84°45	78°15	71°50	81°43
8	69°40	70°46	76°72	84°01	89°09	91°58	87°99	86°90	86°95	84°45	78°16	71°50	81°43
9	69°40	70°48	76°81	84°08	89°12	91°57	87°99	86°91	86°94	84°51	78°19	71°51	81°46
10	69°46	70°54	76°88	84°14	89°15	91°57	88°00	86°93	86°94	84°55	78°22	71°52	81°49
11	69°51	70°65	76°91	84°18	89°17	91°59	88°00	86°94	86°93	84°56	78°25	71°61	81°53
12	69°57	70°70	76°93	84°21	89°20	91°60	88°01	86°94	86°93	84°58	78°28	71°72	81°56
13	69°59	70°74	76°96	84°23	89°24	91°62	88°02	86°95	86°96	84°62	78°32	71°80	81°59
14	69°62	70°76	76°98	84°25	89°26	91°64	88°03	86°96	86°99	84°64	78°36	71°82	81°61
15	69°64	70°78	77°01	84°27	89°27	91°66	88°04	86°96	87°00	84°65	78°39	71°80	81°62

TABLE III.—*Diurnal Variation of ground-temperature at 3 feet depth—continued.*

Hour.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
16	69°66	70°78	77°04	84°28	89°28	91°67	88°05	86°97	87°02	84°63	78°42	71°76	81°63
17	69°67	70°77	77°05	84°30	89°28	91°67	88°06	86°98	87°05	84°63	78°44	71°74	81°64
18	69°67	70°76	77°05	84°31	89°29	91°67	88°06	87°01	87°08	84°62	78°41	71°72	81°64
19	69°66	70°75	77°05	84°30	89°28	91°68	88°05	87°02	87°11	84°62	78°38	71°71	81°63
20	69°65	70°74	77°05	84°30	89°27	91°69	88°03	86°99	87°12	84°61	78°35	71°70	81°63
21	69°65	70°74	77°06	84°30	89°26	91°70	88°02	86°97	87°06	84°60	78°30	71°69	81°61
22	69°64	70°73	77°06	84°30	89°25	91°70	88°00	86°95	87°00	84°59	78°28	71°68	81°60
23	69°61	70°71	77°02	84°25	89°23	91°68	87°99	86°94	86°99	84°58	78°28	71°65	81°58
Mean	69°56	70°63	76°93	84°18	89°19	91°64	88°01	86°94	86°99	84°57	78°28	71°64	81°55
Range	0°27	0°32	0°34	0°30	0°21	0°13	0°08	0°15	0°19	0°18	0°29	0°32	0°21

On the average of the whole year, the diurnal variations at these three depths may be represented approximately by the following periodic formulæ :—

Half inch, $t_1 = 81.01^\circ + 10.866^\circ \sin(n 15^\circ + 230\frac{1}{2}^\circ) + 3.246^\circ \sin(n 30^\circ + 62^\circ)$.

One foot, $t_2 = 80.93^\circ + 0.9186^\circ \sin(n 15^\circ + 123\frac{1}{2}^\circ) + 0.1416^\circ \sin(n 30^\circ - 154^\circ)$.

Three feet, $t_3 = 81.55^\circ + 0.1005^\circ \sin(n 15^\circ - 181\frac{1}{2}^\circ) + 0.0137^\circ \sin(n 30^\circ - 680^\circ)$.

In these formulæ, n stands for the number of hours after midnight.

The diurnal range diminishes very rapidly in the first foot, and comparatively slowly in the next two feet. According to theory, the ranges, at depths increasing in arithmetical progression, should form a decreasing geometric series; and accordingly, if the rate of decrease in the amplitude of the first term, which apparently takes place in the first foot of descent, were to continue, the amplitude at 3 feet depth would be only $(\frac{0.9186}{10.866})^3$ or about $\frac{1}{1100}$ of that observed near the surface, whereas it is nearly $\frac{1}{100}$ of the range at the surface.

It may therefore be inferred that the range at a depth of one foot, deduced from the observations, is much less than it should be. For this there are two reasons. The tube used was much wider than the thermometer frame, and permitted the free interchange of heat between top and bottom by convection currents; and these currents must have had considerable effect in lowering the temperature, since, as we shall see, the mean temperature of the ground is on the average about 5 degrees higher than that of the air. The effect in question was most marked during the short time when a tin cap to the tube was used, but it was not altogether stopped by applying a wooden cap. Again, the maximum temperature, one foot below the ground surface, occurs about 10 P.M., a time when the air temperature is below the mean for the day; and the minimum is reached about 10 or 11 A.M., when the air is hotter than the average, and in most months hotter than the ground at a depth of one foot. The cooling by convection within the tube must therefore have been very active about the time of maximum temperature, while such action was of feeble intensity or altogether absent at the minimum epoch; consequently not only is the mean temperature at one foot depth given by these observations less than it should be, but the

diurnal range must have been much diminished by actions other than the diffusion of heat through the soil. In the 3-foot tube, little or no action of this kind can have taken place, because the rod which carried the thermometer very nearly filled the tube, and also on account of the greater length of the tube, to which the frictional resistance experienced by the convection currents would be proportional. Moreover, the epochs of maximum and minimum at this depth do not differ much from those of the air, and therefore the effect of such convection if it did occur would probably be to increase the range slightly owing to the descent of cold air at the minimum.

The instruments at the new Observatory are provided with narrower tubes, and the deeper thermometers have two or three projections on the rods which almost exactly fill the tubes and effectually stop convection currents. From one year's observations of a thermometer 1 foot below the surface there, the diurnal variation at that depth appears to be the following:—

Hour.	Variation.	Hour.	Variation.
Midnight	+1°08	12	—1°45
1	+0°87	13	—1°36
2	+0°66	14	—1°04
3	+0°42	15	—0°66
4	+0°15	16	—0°13
5	—0°08	17	+0°33
6	—0°36	18	+0°76
7	—0°66	19	+1°10
8	—0°95	20	+1°33
9	—1°18	21	+1°56
10	—1°54	22	+1°46
11	—1°51	23	+1°32

The range is thus 3°1', or nearly twice as great as in Table II.

Except in the case of the surface thermometer, the second periodic terms of the formulæ, above given, must be considered very doubtful, their amplitudes being less than some of the corrections applied in adjusting the hourly means as above described. On comparing the phases of the first terms, it appears that the diurnal heat wave takes about 7 hours and 8 minutes to penetrate to the depth of a foot, and 27 hours 28 minutes to penetrate three feet. From the second terms, the retardations of the semi-diurnal wave amount to 14 hours 24 minutes and 49 hours 28 minutes, respectively; whereas, according to theory, they should be equal to those of the diurnal wave multiplied by $\sqrt{2}$; that is to say, they should be only about 10 and 38½ hours respectively.

The epochs of maximum and minimum, at a depth of half an inch, coincide very closely with those of the air temperature; the minimum occurring about sunrise and the maximum between 13 and 14 hours. At the actual surface of the ground, the maximum would doubtless occur earlier; since at the rate above found the diurnal heat wave would take $27\frac{1}{2}$ hours $\times \frac{\frac{1}{2} \text{ inch}}{3 \text{ feet}}$, or 23 minutes, to penetrate to the first thermometer. This would make the maximum at the surface fall about 1 P.M., which is just midway between the time of greatest

insolation and that of maximum air temperature. The minimum at the surface probably coincides almost exactly with sunrise, though a similar calculation would make it fall at 5 hours 48 minutes *minus* 23 minutes, or 5 hours 25 minutes on the average of the year. The curve at that epoch departs, however, very widely from the simple harmonic type, and the increase of temperature after sunrise is so much more rapid than the decrease just before, that the minimum at the surface probably occurs later and not sooner than at a depth of half an inch; for the waves of short period which we may conceive to be super-added to one of diurnal period in order to produce the observed variation of temperature, die out much more rapidly than the longer waves as they pass down through the soil.

The daily range of the soil temperature is subject to an annual variation, very similar to that of the air temperature in shade, and, at a depth of half an inch, almost exactly equal to the latter in range; or rather the range of the periodic temperature variation, half an inch below the surface, is slightly less than that shown by self-registering thermometers in the shade, though rather greater than that of the true periodic variation of the temperature of the air; these ranges being $23^{\circ}7'$ and $21^{\circ}2'$ respectively; while the range of the means in Table I is $22^{\circ}9'$. The variations of this inequality, from month to month, are also almost identical with those of the temperature range in air. Similar annual variations, though not quite so regular, are shown by the ranges at 1 foot and 3 feet deep; although the latter scarcely exceed the error likely to attach to any single observation, unless the thermometer is read with a very careful avoidance of parallax.

The mean curves of diurnal variation, at the three depths specified, are given in the first three figures of Plate IX:—

ANNUAL VARIATION.

To determine the annual variation, the observations for the whole period of six years and four months are available; for the above tables of hourly means enable us to reduce all the observations to true diurnal means whatever may have been the hours at which the observations were made. The next three tables give the complete series of monthly means for the three depths already mentioned.

TABLE IV.—*Mean ground-temperature at a depth of half an inch.*

YEAR.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1880	...	...	...	...	98.0	99.8	86.4	87.8	86.6	87.0	72.5	63.8	?
1881	62.7	73.5	79.5	95.7	98.5	92.6	87.0	86.5	86.8	80.6	68.1	62.3	81.2
1882	63.1	67.6	81.1	91.1	96.0	90.0	87.2	87.2	87.6	79.0	68.5	61.9	80.0
1883	62.0	62.3	75.3	91.1	95.5	92.4	87.0	88.5	87.2	81.2	70.4	61.6	79.5
1884	64.1	68.3	83.6	90.7	96.5	96.2	87.1	85.7	85.1	77.8	69.0	63.5	80.6
1885	64.3	67.8	85.1	94.5	97.1	100.6	87.7	85.3	87.9	85.1	75.4	62.6	82.8
1886	62.4	68.7	81.1	94.4	99.8	95.9	87.0	86.1	...	...	...	...	?
Mean	63.1	68.0	81.0	92.9	97.3	95.4	87.1	86.7	86.9	81.8	70.7	62.6	81.12

¹ See Volume II, page 111.

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TABLE V.—*Mean ground-temperature at a depth of 1 foot.*

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1880	...	...	...	...	94.6	96.9	87.7	87.3	86.8	84.7	75.4	64.7	P
1881	62.9	71.0	77.8	90.1	96.3	93.5	87.6	87.0	87.3	81.4	70.8	65.2	80.9
1882	65.1	68.7	78.8	87.3	92.5	90.3	87.7	87.6	87.5	81.6	72.5	66.5	80.5
1883	64.8	64.4	74.9	86.4	92.8	91.6	87.2	88.1	86.9	82.0	73.1	64.8	79.8
1884	65.8	69.1	80.3	87.6	93.9	95.6	87.4	86.4	86.7	80.4	72.1	66.5	81.0
1885	66.4	68.7	81.3	89.9	92.4	96.3	87.9	85.5	87.6	85.6	77.8	68.2	82.5
1886	66.0	69.8	80.3	89.9	95.9	94.5	87.5	86.8	...	...	...	...	P
Mean	65.2	68.6	78.9	88.5	94.1	94.1	87.6	87.0	87.1	82.6	73.6	66.0	81.11

TABLE VI.—*Mean ground-temperature at a depth of 3 feet.*

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
1880	...	...	...	...	89.5	92.8	88.7	87.0	87.1	86.0	79.9	71.9	P
1881	68.8	71.9	77.4	84.9	91.0	92.0	88.5	87.2	87.4	84.7	77.6	72.3	82.0
1882	70.4	71.9	77.2	83.9	88.3	89.6	87.7	87.5	86.9	83.9	77.4	72.2	81.4
1883	69.9	68.1	74.0	82.0	88.0	89.4	87.4	87.1	87.0	84.2	78.0	70.8	80.5
1884	69.2	71.0	78.0	84.5	89.7	93.1	88.0	87.0	87.0	82.8	76.4	71.0	81.4
1885	69.6	70.3	78.1	85.7	88.7	93.0	87.9	85.6	86.5	85.8	80.4	73.1	82.1
1886	69.0	70.9	77.8	85.3	91.2	92.2	87.3	86.5	...	...	...	...	P
Mean	69.5	70.7	77.1	84.4	89.5	91.7	87.9	86.9	87.0	84.6	78.3	71.9	81.62

At first sight it might appear that the mean temperatures at the foot of these tables, for the months May, of June, July and August, would need some correction to make the 7-year means for these months strictly comparable with the 6-year means for the other months; especially since, in May and June, the years 1880 and 1886, at the beginning and end of the series, had temperatures higher than the average of the other years. The required correction would in any case be small; but it is purposely neglected, because, as will be shown in the sequel, the temperature of the hottest months (May and June), for the whole period covered by the observations, was probably somewhat under the true mean for these months, while there was no such defect, or at any rate not so great a one in the cold season, the annual range of temperature being greatest in the hottest years.

The monthly means may be approximately represented by the following periodic formulæ:—

Half-inch, $t_1 = 81.12 + 15.366^\circ (\sin n 30^\circ + 293^\circ 2') + 6.036^\circ (\sin n 60^\circ + 265^\circ 20')$.

One-foot, $t_2 = 81.11 + 13.323 (\sin n 30^\circ + 285^\circ 32') + 4.637^\circ (\sin n 60^\circ + 258^\circ 52')$.

Three feet, $t_3 = 81.62 + 10.031 (\sin n 30^\circ + 272^\circ 36') + 3.153^\circ (\sin n 60^\circ + 243^\circ 38')$.

The initial epoch to which the phases refer is the middle of January, and n represents the number of months counted from that data.

The convection currents in the tube of the 1-foot thermometer, which interfered with the diurnal variation of temperature at that depth, can have had no sensible effect on the annual variation. The ratio of the amplitude of the first term, at 1-foot depth, to that at the surface is 0·867, and at 3 feet the amplitude should be decreased in the ratio 0·867³ or 0·652, while the actual ratio of decrease is 0·653. The retardation of phase of the first term, between the surface and 1-foot depth, amounts to $7\frac{1}{2}$ days; while that at 3 feet is 21 days, or very nearly three times as much, which is in close accordance with theory. The semi-annual oscillation is not quite so regular, the diminution of amplitude in the first foot being in the ratio 0·767, the cube of which is 0·453, while the ratio of the amplitude at 3 feet to that at the surface is 0·522.

The mean annual variation, half an inch below the surface, is very similar to that of the air temperature, as will be seen by comparing Table IV with Table VII.

TABLE VII.—Mean air temperature in shade, 4 feet above the ground.

Years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1880	...	...	...	...	91·5	94·3	83·3	84·5	83·0	80·7	67·7	60·1	P
1881	59·1	69·4	74·9	89·4	92·0	89·2	84·5	82·5	83·5	77·8	66·4	60·3	76·8
1882	60·4	64·1	79·6	87·1	90·2	87·8	83·5	82·8	82·8	76·0	64·7	60·0	76·6
1883	59·5	60·9	74·7	88·0	93·1	90·8	84·6	85·4	82·6	76·2	64·8	57·0	76·5
1884	60·4	64·5	79·3	87·0	93·5	92·0	83·5	82·2	81·8	73·9	62·7	58·2	76·6
1885	60·2	61·1	77·2	85·9	88·7	92·6	84·3	81·3	82·5	76·9	66·7	60·1	76·4
1886	59·1	62·5	75·4	86·2	91·3	91·0	83·1	82·8	...	...	...	...	P
Mean	59·8	63·8	76·8	87·3	91·5	91·1	83·8	83·1	82·7	76·9	65·5	59·3	76·8

The range of the monthly means is, however, 2·5° greater on the ground than in the air, the excess temperature of the ground being subject to a semi-annual variation, in which the maxima occur in the months of greatest, and the minima in those of least diurnal range. The monthly differences between the ground temperature and that of the air are the following:—

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
3·3°	4·2°	4·2°	5·6°	5·8°	4·3°	3·3°	3·6°	4·2°	4·9°	5·2°	3·3°	4·3°

The differences are thus greatest in the months when insolation is most powerful and there is least cloud, while the smallest differences occur in the months of December and January when the nights are long and cold; and again in July and August, when the ground is cooled by rain and the sun's rays are intercepted by cloudy skies. The rainfall of the period covered by the observations is here given for comparison.

TABLE VIII.—*Rainfall at the Allahabad Observatory.*

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1880	—	—	—	—	0·38	1·05	9·94	5·41	1·73	...	0·85	0·19	?
1881	0·18	0·04	0·78	...	0·76	5·85	10·70	11·46	3·93	1·17	0·01	...	34·88
1882	...	0·13	...	0·02	0·01	11·11	14·00	10·25	3·14	3·45	0·59	...	42·70
1883	2·68	0·02	0·39	...	0·34	3·87	13·48	2·10	4·92	0·79	...	...	28·81
1884	...	0·18	...	...	0·26	1·62	10·99	9·44	7·31	6·59	...	...	36·39
1885	1·11	...	0·02	0·45	0·53	8·80	9·37	11·83	2·15	0·09	...	2·69	37·04
1886	0·36	0·03	1·12	...	0·26	8·49	9·03	6·76	—	—	—	—	?
Mean	0·72	0·07	0·38	0·08	0·36	5·83	11·07	8·18	3·86	2·02	0·24	0·48	33·29

The excess temperature of the ground is very remarkable, and attention has frequently been called to it by Mr. Blanford's Annual Reports on the Meteorology of India. It is found at every station in India where observations of ground temperature have been made, and is doubtless characteristic of hot countries in general; while there is, in all probability, a difference in the opposite direction between the air and ground temperatures in high latitudes; for, owing to the circulation of the atmosphere and the constant mixing together of its different parts, the air temperature must be more uniform all over the earth than it would be, were it determined, for each place, solely by the balance between insolation and loss of heat by radiation into space; while the temperature of the ground is more directly dependent on the balance between the gain and loss of heat by radiation. The amount of this excess, as shown by the observations, averages $4\cdot3^{\circ}$; but just as it is greatest in the hottest months of the average year, so it is probably greater in hot years than in cool ones. For instance, the excess in May 1880 was $6\cdot5^{\circ}$; and, in May 1886, $8\cdot5^{\circ}$; in which years we have reason to believe, as will be shown below, that the insolation was greater and the mean temperature higher, than at any other part of the period covered by the observations; whilst in the year of least insolation, 1883, the excess in May was only $2\cdot4^{\circ}$. Now during the $6\frac{1}{2}$ years given in the table, the mean air temperature was almost uniformly below the average for many years; and presumably, the ground temperature and its excess above that of the air were also less than the average. We shall therefore probably not be far wrong if we take the true mean temperature of the ground surface to be about 5° above that of the air.

At the greater depths, the annual variation is similar to that observed near the surface, the depths not being sufficient to produce any considerable difference of phase. The ranges are, however, reduced in the ratios above given. The second set of curves on the left hand of Plate IX show the annual variation of the monthly means.

At a depth of 1 foot, the mean temperature appears from the observations to be identical with that at the surface, while at three feet deep it is half a degree higher. For reasons above set forth, however (page 141), there can be no doubt that the observed temperature at a depth of 1 foot is slightly too low, and its true value will probably be something intermediate between the temperatures given by the other two thermometers.

The true means for the period covered by the observations should therefore probably be something like the following :—

Half-inch	81.1°.
One foot	81.3°.
Three feet	81.6°.

This increase of half a degree, in three feet of descent, at once suggests some source of heat in the soil a few feet below the surface, for no such rapid rate obtains at great depths, except perhaps in the immediate vicinity of volcanic vents. Indeed, the source of heat must lie above the permanent underground water-level, which is about 60 feet below the surface; for, during the six years of observation, I have from time to time taken the temperature of the water, drawn from a deep well in the same garden, and found it, always between 82° and 83°; the latter figure being approached when the bucket had been for some hours in constant action, so that the water drawn had just entered the well, and consequently showed the true temperature of the surrounding strata. If the temperature increased downward at the rate just found, the well water would be ten degrees hotter than the ground surface, but it is only one or two degrees hotter. If it increases at the average rate of about 1° Fahrenheit in 60 feet, as it does in most parts of the world, the true mean temperature near the surface, for a long term of years, will probably be about 82° Fahrenheit. This is higher than any of the three temperatures above given, the observations having been made, as above pointed out, during years which were, on the whole, considerably cooler than usual; and the suggestion at once arises that the source of heat a few feet below the surface, which causes the rapid increase of temperature observed, is nothing else than the store accumulated in the soil during the hot years, 1876—79, and afterwards gradually dissipated by upward diffusion.

In explanation of a similar rapid increase of temperature in the first three feet at Alipore, Mr. Blanford has suggested the heat due to gradual oxidation of a layer or layers of peaty matter, underlying the whole neighbourhood of Calcutta; but no such explanation is applicable here, the soil being singularly free from organic matter of every kind.

That the accumulation of heat in the soil, during previous hot years, is the true explanation of the facts observed at Allahabad, can hardly be doubted, when we compare the annual means of Tables IV and VI, thus :—

	1881.	1882.	1883.	1884.	1885.
Temperature at 3 feet	82.0°	81.4°	80.5°	81.4°	82.1°
„ at half an inch	81.2	80.0	79.5	80.6	82.8
Excess at 3 feet	+0.8	+1.4	+1.0	+0.8	—0.6

During the first 2½ years, the temperature was falling, and throughout this part of the period and the first 1½ years of the rise the temperature at 3 feet deep was higher than at the surface; the greatest difference occurring about a year before the minimum temperature was reached. In the last year, however, when the temperature was rising towards a maximum, the upper thermometer was the hotter of the two, indicating that the effect of the new heat wave was not yet fully felt at a depth of 3 feet.

CONDUCTIVITY OF THE SOIL.

The periodic formulæ for the diurnal and annual variations, given in the preceding sections, enable us to determine the thermal conductivity of the soil, or rather its “diffusivity,” as defined by Professor Everett, in a note attached to the section

of his translation of Deschanel's Natural Philosophy, which treats of heat. This diffusivity is the ratio of the thermal conductivity, as usually defined, to the thermal capacity per unit of volume, or in Fourier's notation it is equal to $\frac{K}{CD}$. Everett represents it by κ . The integral of Fourier's equation for the temperature at any point in an infinite solid, subjected to periodic changes of temperature at the surface, is given by the sum of such terms as $V = e^{\alpha x} \sin(\beta t - \alpha x)$, with a constant term added, where x represents the depth, t the time angle, and α and β two constants connected by the relation $\frac{\beta}{2\alpha^2} = \kappa$.

The observed temperature may be represented as above by equations of the form,

$V = A_0 + [A_1 \sin(\beta_1 t + E_1) + A_2 \sin(\beta_2 t + E_2) + \&c.]$, where $\beta_1 = \frac{2\pi}{T}$, $\beta_2 = \frac{4\pi}{T}$, &c., T standing for the periodic time.

Comparing similar terms in the two formulæ we find

$$\begin{aligned} \alpha_1 &= \sqrt{\frac{\beta_1}{2\kappa}} = \sqrt{\frac{\pi}{T\kappa}} \\ \alpha_2 &= \sqrt{\frac{\beta_2}{2\kappa}} = \sqrt{\frac{2\pi}{T\kappa}} \\ &\quad \&c. \qquad \&c. \end{aligned}$$

Then since $A_1 = e^{\alpha_1 x}$, $A_2 = e^{\alpha_2 x}$, &c., we have, by comparing these terms at different depths,

$$\frac{\log_e A_1}{x} - \frac{\log_e A_1'}{x'} = \alpha_1 = \sqrt{\frac{\pi}{T\kappa}}, \text{ and}$$

$$\frac{\log_e A_2}{x} - \frac{\log_e A_2'}{x'} = \alpha_2 = \sqrt{\frac{2\pi}{T\kappa}}; \text{ that is to say, the quantity}$$

$\sqrt{\frac{\pi}{T\kappa}}$ is given by dividing the difference of the Napierian logarithms of the amplitudes of the first periodic term by the difference of depths, or by performing a similar computation for the second term and dividing by $\sqrt{2}$. If we take as unit of time the length of the period the same processes give us $\sqrt{\frac{\pi}{\kappa}}$. Again, since $E_1 = \alpha_1 x$ and $E_1' = \alpha_1 x'$, we have $\alpha_1 = \frac{E_1 - E_1'}{x - x'}$ and $\alpha = \frac{E_2 - E_2'}{x - x'}$, which make the above quantity equal to the difference of the phases of the first term (in circular measure) divided by the difference of depth, or to a similar result derived from the second term and divided by $\sqrt{2}$.

Applying these methods to the diurnal variation, we get the values given in Tables IX and X.

TABLE IX.—*Amplitudes and Phases of Diurnal and Semi-diurnal Variations.*

DEPTH.	Log _e A ₁	Log _e A ₂	CIRCULAR MEASURE OF	
			E ₁	E ₂
0.042 Ft.	2.3834	1.1774	4.0229	1.0821
1.0 "	—0.8491	—0.1955	2.1554	—2.6877
3.0 "	—2.2974	—4.2037	—3.1678	—12.1825

TABLE X.—*Deduced Values of $\sqrt{\frac{\pi}{\kappa}}$.*

DEPTH.	From A ₁ .	From E ₁ .	From A ₂ .	From E ₂ .
$\frac{1}{2}$ inch & 1 Ft.	3'374	1'949	1'014	3'935
1 ft. & 3 ft.	0'724	2'662	1'417	4'747
$\frac{1}{2}$ inch & 3 ft.	1'583	2'431*	1'262	4'484
Mean	1'894	2'347	1'231	4'389

These results, as might be expected from the error attaching to the readings of the 1 foot thermometer, and the very small amplitudes of both terms at a depth of 3 feet, are by no means consistent, and must be assigned very little weight, in comparison with those derived from the annual variation. Their general mean is 2'465, which may be reduced to the corresponding value, where the unit of time is a year, by dividing by $\sqrt{365 \cdot 24}$, when it becomes 0'12905.

From the annual variation we get the results in Tables XI and XII.

TABLE XI.—*Amplitudes and Phases of Annual and Semi-annual Variation.*

DEPTH.	Log _e A ₁ .	Log _e A ₂ .	CIRCULAR MEASURE OF	
			E ₁ .	E ₂ .
0'042 Ft.	2'7302	1'7977	5'1134	4'6301
1'0 „	2'5803	1'5340	4'9826	4'5172
3'0 „	2'3057	1'1482	4'7569	4'2514

TABLE XII.—*Deduced Values of $\sqrt{\frac{\pi}{\kappa}}$.*

DEPTH.	From A ₁ .	From E ₁ .	From A ₂ .	From E ₂ .
$\frac{1}{2}$ inch and 1 Ft.	0'1565	0'1364	0'1947	0'0833
1 foot and 3 „	0'1373	0'1129	0'1364	0'0940
$\frac{1}{2}$ inch and 3 „	0'1435	0'1205	0'1553	0'0905
Mean	0'1458	0'1249	0'1621	0'0893

The two columns of values derived from the first term are fairly consistent, and their mean is 0'13535. Those derived from the second term differ, in some cases, by more than 50 per cent., and are therefore by no means so trustworthy. Their mean is 0'1257.

In striking a general mean, the former of these numbers should be allowed at least double weight, whilst the latter and that deduced from the diurnal variation are each given single weight. In other words, the mean of 3 independent calculations, on the basis of the annual term, is estimated to be at least as nearly correct as that of six computations from the semi-annual term, or as the mean of 12 independent computations from the

diurnal variation. This general mean is 0.13136, the unit of time being a year and that of length a foot.

This value is considerably higher than those found by Dr. Everett for various places in the vicinity of Edinburgh, which vary from 0.0674, at Craighleith Quarry, to 0.1156 at Calton Hill. I think, however, there can be little doubt that the value just found is, if anything, too low, since the most trustworthy data give the highest result. The simple mean of the three weighted values, above given, would be 0.13004; and if the results derived from the diurnal and annual variations be considered of equal accuracy, their general mean is 0.1298. Whatever combination of computed values be adopted therefore as giving the most probable mean value, there is no sensible difference in the result, which still remains about 0.13.

A large value of $\sqrt{\frac{\pi}{\kappa}}$ means a small value of κ , whence we infer that heat diffuses through the soil at Allahabad much less rapidly than in Scotland, or even at Bombây, where Mr. C. Chambers has found the mean value of $\sqrt{\frac{\pi}{\kappa}}$ to be 0.1149.¹ This may possibly have something to do with the composition of the soil, which contains less iron than the trap rock of Bombay or of Calton Hill, but the effect is no doubt principally due to its dryness. For eight or nine months of the year, the soil at Allahabad is quite dry to the touch, and there can be no diffusion of a heat by the circulation of water; whereas, in the British Isles, at a depth of a few inches below the surface, the soil is in most places constantly saturated with water; and at Bombay, where the thermometers were also enclosed in highly conducting brass tubes, a similar condition obtains for some five or six months every year. By deducing the ratio of the κ 's from the values of $\sqrt{\frac{\pi}{\kappa}}$ we find that the diffusivity through the wet sandstone of Craighleith is 3.8 times that through the dry loam of Allahabad. In this respect, it will be interesting to compare the diffusivity through the wet soil of Alipore near Calcutta with that in the dry sandy soil of Jeypore in Rajputana, where ground thermometers at various depths down to 20 feet have been in use for some years.

From the value of $\sqrt{\frac{\pi}{\kappa}}$ above adopted, we find $\kappa = 182.064$ when the units are the foot and the year. This may be reduced to C. G. S. measure by multiplying by the square of the number of centimetres in a foot and dividing by the number of seconds in a year. It then becomes 0.0054.

The density of the soil in the month of January, when it probably contains about the average quantity of moisture, has been found to be 1.526 grams per cubic centimetre. To determine this, the surface soil was stripped off to a depth of 15 inches, and an inverted cylindrical tin vessel of 320.5 cubic centimetres capacity, was pressed down into the undisturbed layer beneath, until its bottom was flush with the surface of this layer. The tin was then dug out and the block of earth which filled it was found to weigh 489 grams. The specific gravity of the powdered soil was found by the flask method to be 2.294, whence we must conclude that, in the soil in its ordinary condition, one-third of the volume consists of air cavities.

The chief mineral constituents being silica (nearly 90 per cent), alumina and carbonate of lime, with some water, the specific heat is probably about 0.21; consequently the thermal capacity per unit volume is about $1.526 \times 0.21 = 0.3205$. The conductivity, κ , as

¹ Meteorology of the Bombay Presidency, page 71.

TABLE XVII.—Mean Rainfall of each month, freed from Annual Variation.

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1880	...	...	...	...	...	...	...	...	...	...	1'95	2'19
1881	2'48	2'73	2'90	2'94	2'93	2'91	2'89	2'87	2'84	2'88	3'05	3'26
1882	3'38	3'41	3'44	3'51	3'59	3'67	3'75	3'79	3'80	3'72	3'52	3'19
1883	2'87	2'65	2'51	2'44	2'35	2'27	2'20	2'15	2'15	2'11	2'01	1'97
1884	2'11	2'43	2'76	2'95	3'05	3'08	3'10	3'12	3'13	3'25	3'44	3'64
1885	3'69	3'50	3'20	2'99	2'97	3'02	3'05	3'07	3'07	3'05	2'95	2'81
General mean for 62 months, 2'95 inches.												

These curves at once suggest that some portion of the residual variations of ground temperature, and a considerable portion of those of the temperature of the air, are caused by variations of rainfall; the rule being that heavy rain produces low temperature; a relation between cause and effect to which attention has often been called by Mr. Blanford. Nevertheless, underlying these minor fluctuations, we find in the ground temperature curves, and to a much less extent in the air, a gradual downward tendency to a minimum in the early part of 1883, followed by an upward tendency to the end of the observations, and of this the variations of rainfall appear to give no sufficient explanation; for though the rainfall was excessive in 1882, it was less in 1883 than in any other year of the five.

The only adequate cause that can be suggested for such a variation of long period, seemingly independent of the rainfall, and much more strongly marked in the temperature of the ground surface than in that of the air, is an inequality in the amount of heat received from the sun. That such an inequality exists can hardly be doubted, because a variation, which appears to be inexplicable in any other way, is seen in the averages of the solar thermometer observations and in those of air temperature made at all the Meteorological stations in India during the last ten years; and Köppen long ago showed that a similar variation of temperature is found at all tropical stations.

At Allahabad the same solar thermometer (black-bulb *in vacuo*) was used under almost identical conditions for the 10 years, 1876—85, and the observations are therefore more trustworthy than those of any station where the instrument has been changed. In the Journal of the Asiatic Society of Bengal, Volume LV, Part II, page 316, I have given an analysis of the observations made on clear days, from which the following values of the so-called "Solar Constant," in degrees of the instrument used, are deduced:—

YEARS.	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.
Solar constant . .	82'8	85'1	85'2	83'6	82'7	81'8	79'6	78'6	80'4	83'1

These numbers are all founded on monthly averages, the cloudy months, July to September.

ber, being, however, left out. The epoch, to which the value for each year properly refers, is therefore May 4th instead of July 1st.

The values of the "Solar Constant" above given are very evidently subject to a periodic oscillation, in which the maximum approximately coincides with the sunspot minimum, which occurred in 1878, and the minimum with the maximum of sunspots, which occurred in 1883. Without stopping to discuss the mode in which such a variation might be brought about by actions going on in the sun, or even to say whether the variation is real or only apparent, on both of which questions there is likely to be some controversy in the future as there has been in the past, we may pass on to inquire whether any distinct relation can be traced between these assumed values of the sun's heating power and the observed variations of ground temperature. The sunspot period is variable, and its mean value is not very exactly defined, but it is usually taken to be about 11 years. As regards a fraction of one period, no considerable error will be introduced by taking it at 10 years, on which assumption the angular value of a month is 3 degrees, and the calculation of the monthly ordinates of a harmonic curve is thereby much facilitated. Assuming this value of the period, the simple harmonic variation, deduced from the values above given, will be represented by the formula.

$S = 82.29^\circ + 2.817^\circ (\sin n 3^\circ + 192^\circ)$, where n is the number of months, counted from the middle of November 1880, which is the initial point of the curves on Plate IX.

For the air temperature and the rainfall we have also the observations of 10 complete years, *viz.*,—

Y EAR .	1876.	1877.	1878.	1879.	1880.	1881.	1882.	1883.	1884.	1885.
Air temperature . . .	77°0'	78°3'	78°6'	77°1'	77°5'	76°8'	76°6'	76°5'	76°6'	76°4'
Rainfall	38°82"	21°31"	26°21"	42°35"	20°34"	34°88"	42°70"	28°81"	36°39"	37°04"

With reference to the same epoch as before, the temperature, freed from annual variation, may be represented approximately by the formula

$$T = 77.14 + 0.857 (\sin n 3^\circ + 171\frac{1}{2}^\circ)$$

and the monthly rainfall, similarly equalized, by the formula

$$R = 2.69'' + 0.35'' (\sin n 3^\circ + 1\frac{1}{2}^\circ).$$

The air temperature therefore attains a maximum or minimum about 7 months later than the insolation, and the rainfall a maximum about $3\frac{1}{2}$ months after the minimum of solar heat. The range of variation of the former would be about 1.7° were it subject to no other fluctuations than those represented by the harmonic wave, and the range of the regular periodic variation of the rainfall apparently amounts to about 26 per cent. of the average, or the rainfall of the year varies between narrower limits than 113 and 87 per cent. This is very much less than the absolute range due to all causes, which during the ten years compared amounted to nearly 70 per cent. of the average.

With regard to ground temperatures we have to assume not only a period but a mean value, since the observations do not extend over a whole period. To begin with, the observations made with the 1 foot thermometer may be rejected on account of the error affecting them. The error was considerably greater at the commencement of the series,

when a tin cap to the tube was used, than it afterwards became, and this is an additional reason why the observations should not be used in attempting to determine variations of long period. The true mean temperatures at the surface and at a depth of 3 feet, doubtless do not differ by more than the probable error of either, as deduced from 6 years' observations; so they may be taken equal. Now when two harmonic curves of the same period, but differing in phase and amplitude, are drawn about the same axis of abscissæ, the ordinates at the points where they intersect are alternately positive and negative, and the sum of any two, taken consecutively, will be zero; or if to all the ordinates a constant be added, the mean of any two successive ordinates will be this constant. The mean of the ordinates at any two consecutive points of intersection of figures 7 and 9, Plate IX, should therefore give us the true mean temperature of the ground near the surface, were it not for disturbances caused by oscillations of short period.

The descending curves cross in January 1881, the measure of the ordinate being 82.21° . Were the curves free from minor inequalities, they might be expected to intersect again in their ascending segments about five years later. They intersect however in December 1884, at 81.44° , and again in the descending segment of a minor oscillation, in January 1886, at 82.14° ; and presumably they would again intersect on the rise a few months later on; but this cannot be ascertained. Taking the mean of the two ordinates last given and combining it with the first, we find the resulting mean value to be 82° , which is exactly the same as the probable value of the soil temperature inferred from that of the water drawn from a deep well.

With the aid of this mean value, we can now compute the co-efficients of the formulæ of sines, for the harmonic variations underlying the oscillations in figures 1 and 3. With reference to the epoch, November 15th, 1880, these are:—

$$\begin{aligned}\text{Surface, } t &= 82.0^\circ + 2.086^\circ (\sin n 3^\circ + 195^\circ 45'). \\ 3 \text{ Feet, } t &= 82.0^\circ + 0.892^\circ (\sin n 3^\circ + 177^\circ 45').\end{aligned}$$

The amplitude of the oscillation at a depth of three feet is very nearly equal to that of the air temperature, and their phases are almost identical, differing only by two months. At the surface, the amplitude is very much greater, and the difference of phase between the surface and three feet is rather more than it ought to be, according to the co-efficient of diffusivity already determined. It may therefore be inferred that, at the surface, the minor oscillations do not completely cancel each other, in the interval over which the observations extend.

The curve for a depth of three feet being freer from irregularities than that of only half an inch below the surface, its minimum epoch, which falls in June 1883, may be looked upon as more exactly determined than that for the surface. The minimum of the latter falls about a month before that of solar radiation, while in the curves for the ground temperature, three feet below the surface, and also for the air temperature, there is a difference of several months in the opposite direction. It seems probable therefore that the variation of solar heat is the cause of the variation of the first order, both in the air temperature and in that of the ground, the slight difference of phase in the wrong direction observed on comparing the harmonic curves of the sun's heat and the surface temperature, being due to the uncertainty of the latter.

The harmonic curves represented by the preceding formulæ are shown in figures 1, VOL. IV. W 2

2, 3, 4 and 5, Plate X. The values of their ordinates are given in the following tables:—

TABLE XVIII.—*Ordinates of the Harmonic Curve of Solar Radiation.*

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1880	...	...	...	...	...	...	...	...	...	...	81°70	81°56
1881	81°42	81°28	81°14	81°01	80°86	80°76	80°63	80°52	80°41	80°30	80°20	80°10
1882	80°01	79°93	79°85	79°78	79°72	79°66	79°61	79°57	79°54	79°51	79°49	79°48
1883	79°47	79°48	79°49	79°51	79°54	79°57	79°61	79°66	79°72	79°78	79°85	79°93
1884	80°01	80°10	80°20	80°30	80°41	80°52	80°63	80°76	80°88	81°01	81°14	81°28
1885	81°42	81°56	81°75	81°85	82°00	82°14	82°29	82°44	82°59	82°73	82°88	83°02

TABLE XIX.—*Ordinates of the Harmonic Curve of Ground Temperature half an inch below the surface.*

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1880	...	...	...	...	...	...	...	...	...	...	81°43	81°33
1881	81°23	81°13	81°03	80°93	80°84	80°75	80°67	80°59	80°51	80°43	80°36	80°30
1882	80°24	80°18	80°13	80°09	80°05	80°01	79°98	79°96	79°94	79°92	79°92	79°91
1883	79°92	79°93	79°94	79°96	79°99	80°03	80°06	80°11	80°15	80°21	80°27	80°33
1884	80°40	80°47	80°55	80°63	80°71	80°80	80°89	80°98	81°08	81°18	81°28	81°38
1885	81°49	81°59	81°70	81°81	81°92	82°03	82°14	82°25	82°35	82°46	82°57	82°67

TABLE XX.—*Ordinates of the Harmonic Curve of Ground Temperature 3 feet below the surface.*

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1880	...	...	...	...	...	...	...	...	...	...	82°03	81°99
1881	81°94	81°90	81°85	81°80	81°76	81°71	81°67	81°63	81°59	81°55	81°51	81°47
1882	81°42	81°38	81°35	81°32	81°30	81°28	81°25	81°23	81°20	81°18	81°17	81°15
1883	81°14	81°13	81°12	81°12	81°11	81°11	81°11	81°12	81°13	81°14	81°15	81°16
1884	81°18	81°19	81°21	81°24	81°26	81°29	81°32	81°35	81°38	81°41	81°45	81°49
1885	81°53	81°57	81°61	81°65	81°69	81°74	81°78	81°83	81°87	81°92	81°97	82°01

TABLE XXI.—*Ordinates of the Harmonic Curve of Air Temperature.*

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1880	...	...	...	...	...	...	...	...	...	...	77°24	77°19
1881	77°15	77°10	77°06	77°01	76°97	76°92	76°88	76°84	76°80	76°76	76°72	76°68
1882	76°64	76°61	76°57	76°54	76°51	76°48	76°45	76°42	76°40	76°38	76°36	76°34
1883	76°32	76°31	76°30	76°29	76°29	76°28	76°28	76°28	76°29	76°29	76°30	76°31
1884	76°32	76°34	76°35	76°37	76°39	76°41	76°44	76°47	76°50	76°53	76°56	76°59
1885	76°63	76°67	76°70	76°74	76°78	76°83	76°87	76°91	76°95	77°00	77°04	77°09

TABLE XXII.—*Ordinates of the Harmonic Curve of Monthly Rainfall.*

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1880	...	...	...	...	...	...	...	...	...	...	2°70	2°72
1881	2°74	2°76	2°77	2°79	2°81	2°82	2°84	2°86	2°87	2°89	2°90	2°92
1882	2°93	2°94	2°96	2°97	2°98	2°99	3°00	3°01	3°01	3°02	3°03	3°03
1883	3°03	3°04	3°04	3°04	3°04	3°04	3°04	3°03	3°03	3°03	3°02	3°01
1884	3°01	3°00	2°99	2°98	2°97	2°96	2°94	2°93	2°92	2°90	2°89	2°87
1885	2°86	2°84	2°82	2°81	2°79	2°77	2°76	2°74	2°72	2°70	2°68	2°66

On the assumption that the periodic terms of the formulæ last given are approximately correct, both in phase and amplitude, we can make a second approximation to the true mean of the surface temperature for a long term of years. If the oscillations of short period more or less completely cancel each other in 6 or 7 years, the error of the average for such a term of observation will be found by evaluating the integral $\int_{\theta_0}^{\theta} a \sin d \theta$, and dividing it by $\theta - \theta_0$, the difference of phase of the long-period oscillation corresponding to the time covered by the observations. Taking in the whole time represented in Tables IV and VI, the constants have the following values:—

	Surface.	3 Feet.
a	2°086'	0°892'
θ	384° 45'	366° 45'
θ_0	177° 45'	159° 45'

The error of the mean of Table IV is therefore $-2°086' \times \frac{1°073'}{3°542'} = -1°12'$, and that of Table VI is $-0°892' \times \frac{1°073'}{3°542'} = -0°49'$. These results would make the true mean for the surface $81°12' + 1°12' = 82°24'$, and that for the stratum three feet deep $81°64' + 0°49' = 82°13'$. Both results indicate that the mean assumed in computing the constants of the

harmonic formula is slightly too low. Their difference, $0^{\circ}11'$, is negligible, but it indicates that the amplitude found for the long period variation at the surface is probably a little too great, the minor oscillations not having completely cancelled one another. If we take the result found for the stratum three feet deep to be the true mean temperature of the soil, it is exactly 5 degrees higher than that of the air, the 10-year average of which is $77^{\circ}14'$, while that of 19 or 20 years is between $77^{\circ}1'$ and $77^{\circ}2'$.

This great excess is probably local and due to the circumstance that the trees surrounding the Observatory site act as a heat trap, as far as the ground is concerned, preventing the free radiation of heat into space at night and the free circulation of the air by day; while, when the sun is high in the heavens, insolation produces its full effect. The result is that the temperature does not fall so low at night or in the cold season as it would on a more open site, whilst at midday and in the hot season the temperature attained is higher than it would be where the air circulated more freely. The observations of air temperature, radiation and wind at the new Observatory prove the truth of these remarks, and the excess temperature of the soil there appears to be only about $3^{\circ}5'$.

Since the periodic variation of rainfall is nearly opposite in phase to that of the temperature both in the air and in the ground, and since a glance at Figures 8 and 9 on Plate X suffices to show that, as regards the irregular or abnormal variation, rainfall is probably the cause, and temperature variation the effect, it may be contended that the same rule holds with the regular or periodic variation also, and even that the inequality of the rainfall is in some unexplained way the cause of the apparent variation in the sun's heating power. The best way to investigate this question will probably be to compare the supposed effects of a given variation of rainfall taking place (1) regularly in the 10-year period, and (2) irregularly or abnormally, that is to say, in short periods of length at present undefined. Neglecting the slight departures from complete opposition of phase between the rainfall and temperature inequalities we find that, as regards the periodic variation, an increase of $0^{\circ}35'$ in the mean monthly rainfall, or 13 per cent., lowers the air temperature $0^{\circ}857'$, that of the ground surface $2^{\circ}086'$, and that of a stratum 3 feet deep $0^{\circ}892'$, or that an increase of 1 per cent. in the rainfall produces the following temperature depressions:—

Air	.	.	.	.	.	.	.	.	.	$0^{\circ}066'$
Ground surface	.	.	.	.	.	.	.	.	.	$0^{\circ}160'$
Ground, 3 feet deep	.	.	.	.	.	.	.	.	.	$0^{\circ}068'$

To measure the effect of the irregular or abnormal variations we must first determine these by taking the differences between the figures in Tables XIII, XV, XVI and XVII, and those in Tables XIX, XX, XXI and XXII. These differences are given in the next four tables, and they are charted in Figures 16, 17, 18 and 19, which show the relation between temperature and rainfall variations even more clearly than Figures 7, 9, 10 and 11, Plate IX.

¹ The old observatory grounds do not act as an accumulator of heat as far as the air is concerned, but the reverse. They lie in a hollow in which cool air collects during the nights which are almost invariably calm, consequently the mean air temperature is about half a degree lower than at the new Observatory. The diurnal maxima are higher, however, the difference in the hottest months amounting to about 2 degrees.

² It is best to express the rainfall variation as a percentage of the average; for while the temperature variations of the last ten years appear to have been of normal range, the rainfall was much less than usual, the average being only 32.3 inches, while the average for upwards of 30 years is about 39 inches.

TABLE XXIII.—*Abnormals of Ground Temperature half an inch below surface.*

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1880 . . .	...	...	...	...	...	...	...	...	...	...	+1'09	+1'00
1881 . . .	+0'98	+0'97	+0'82	+0'61	+0'44	+0'36	+0'28	+0'19	+0'07	-0'06	-0'20	-0'23
1882 . . .	-0'17	-0'09	-0'04	-0'03	-0'03	-0'10	-0'33	-0'66	-0'85	-0'90	-0'85	-0'77
1883 . . .	-0'72	-0'68	-0'59	-0'50	-0'43	-0'31	-0'01	+0'37	+0'64	+0'76	+0'82	+0'85
1884 . . .	+0'73	+0'48	+0'20	-0'02	-0'13	-0'19	-0'24	-0'25	-0'20	-0'10	0	+0'05
1885 . . .	+0'03	+0'12	+0'37	+0'67	+0'79	+0'70	+0'49	+0'27	+0'11	-0'06	-0'23	-0'44

TABLE XXIV.—*Abnormals of Ground Temperature 3 feet below the surface.*

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1880 . . .	...	...	...	...	...	...	...	...	...	...	+0'20	+0'24
1881 . . .	+0'28	+0'31	+0'30	+0'26	+0'25	+0'33	+0'41	+0'46	+0'43	+0'33	+0'20	+0'11
1882 . . .	+0'11	+0'12	+0'12	+0'11	+0'11	+0'06	-0'08	-0'29	-0'45	-0'54	-0'58	-0'58
1883 . . .	-0'58	-0'56	-0'53	-0'52	-0'53	-0'54	-0'45	-0'25	-0'02	+0'19	+0'38	+0'51
1884 . . .	+0'55	+0'51	+0'42	+0'31	+0'24	+0'19	+0'16	+0'13	+0'12	+0'09	+0'04	-0'04
1885 . . .	-0'14	-0'19	-0'12	+0'06	+0'22	+0'28	+0'27	+0'21	+0'20	+0'19	+0'17	+0'13

TABLE XXV.—*Abnormals of Air Temperature.*

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1880 . . .	...	...	...	...	...	...	...	...	...	...	+0'76	+0'68
1881 . . .	+0'64	+0'62	+0'55	+0'49	+0'48	+0'47	+0'47	+0'48	+0'49	+0'46	+0'37	+0'32
1882 . . .	+0'31	+0'29	+0'24	+0'16	+0'10	+0'03	-0'13	-0'32	-0'42	-0'32	-0'11	+0'10
1883 . . .	+0'27	+0'36	+0'41	+0'39	+0'32	+0'32	+0'46	+0'69	+0'83	+0'90	+0'91	+0'86
1884 . . .	+0'74	+0'56	+0'39	+0'25	+0'17	+0'10	-0'04	-0'24	-0'47	-0'68	-0'84	-0'91
1885 . . .	-0'93	-0'92	-0'81	-0'62	-0'47	-0'42	-0'45	-0'51	-0'54	-0'56	-0'58	-0'64

TABLE XXVI.—*Abnormals of Rainfall.*

YEARS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
1880 . . .	...	...	...	...	...	...	...	...	...	...	-0'75	-0'53
1881 . . .	-0'26	-0'03	+0'13	+0'15	+0'12	+0'09	+0'03	+0'01	-0'03	-0'01	+0'15	+0'34
1882 . . .	+0'45	+0'47	+0'48	+0'54	+0'61	+0'68	+0'75	+0'78	+0'79	+0'70	+0'49	+0'16
1883 . . .	-0'16	-0'39	-0'53	-0'60	-0'69	-0'77	-0'84	-0'88	-0'88	-0'92	-1'01	-1'04
1884 . . .	-0'90	-0'57	-0'23	-0'03	+0'08	+0'12	+0'16	+0'19	+0'21	+0'35	+0'55	+0'77
1885 . . .	+0'83	+0'66	+0'38	+0'18	+0'18	+0'25	+0'29	+0'33	+0'35	+0'35	+0'27	+0'15

162 GROUND TEMPERATURE OBSERVATIONS, OLD OBSERVATORY, ALLAHABAD.

The sum of all the positive abnormals of rainfall is $14^{\circ}59''$, and that of all the negatives is $12^{\circ}05''$. The sums of the variations of temperature for the same months are:—

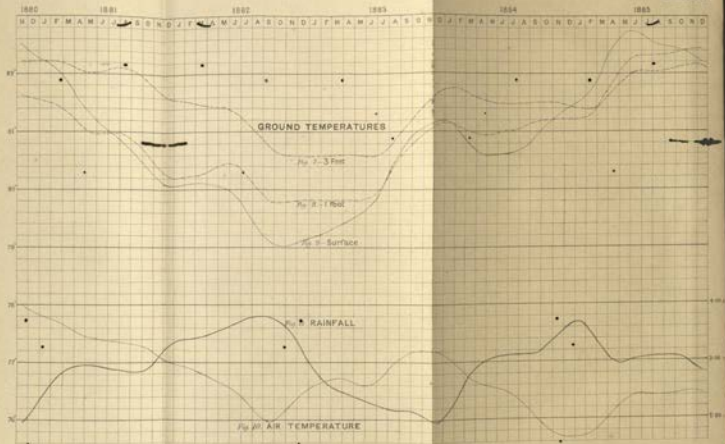
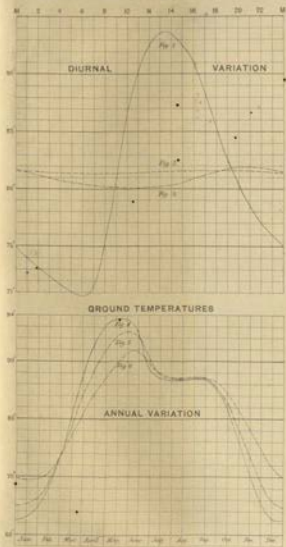
	SUM OF TEMPERATURE ABNORMALS.		
	Ground Surface.	Ground, 3 feet deep.	Air.
Rainfall Variation Positive	$-0^{\circ}79^{\circ}$	$+2^{\circ}69^{\circ}$	$-6^{\circ}54^{\circ}$
Rainfall Variation Negative	$+5^{\circ}64$	$+0^{\circ}51$	$+12^{\circ}51$

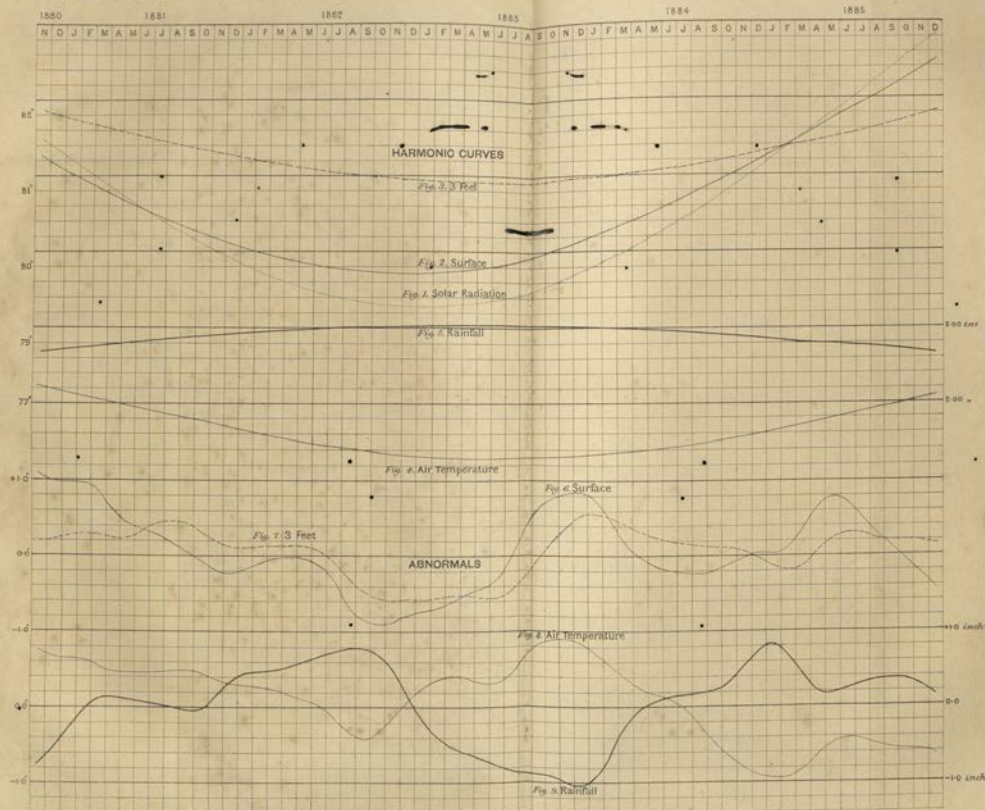
The rule that a scanty rainfall is accompanied by high temperature is therefore apparently more generally true than the converse, which during the years of observation was not true for the stratum 3 feet below the surface. Combining both lines in the above table we find that a variation of $26^{\circ}64$ inches in the monthly rainfall produces a change of $6^{\circ}43^{\circ}$ in the opposite direction in the temperature of the ground surface, one of $2^{\circ}18^{\circ}$ in the same direction at a depth of 3 feet and one of $19^{\circ}05^{\circ}$ in the opposite direction in the air. This total variation is equal to 990 per cent. of the mean monthly rainfall; therefore a variation of 1 per cent. would produce the following temperature changes:—

Air	$-0^{\circ}0192^{\circ}$
Ground surface	$-0^{\circ}0065$
Ground, 3 feet deep	$+0^{\circ}0022$

Comparing these figures with those given on page 158, it is seen that while the air temperature is very decidedly affected by the rainfall according to the rule already mentioned, the effect of these irregular variations is only between one-third and one-fourth as great in proportion to their amount as that of the regular cyclical variation must be if the periodic variation of temperature be caused by variations of rainfall. The effect upon the temperature of the ground surface is only one-twenty-fifth part as great as it should be if all the inequalities shown in Figure 9, Plate IX, were the effect of rainfall variations only, whilst at a depth of 3 feet an irregular increase of rainfall seems to have no cooling effect whatever, but rather the reverse.

It must therefore be concluded that although a large part of the variation of air temperature at Allahabad from year to year is the effect of inequalities of rainfall, such is not the case with the temperature of the ground, for which another cause must be sought, and there can be little doubt that this is a variation in the solar heat, which is perfectly capable of producing all the supposed "periodic" inequalities already mentioned, whilst some at least of the minor oscillations of temperature may be due to short period inequalities of solar activity such as have been discovered by Professor Balfour Stewart.





CORRIGENDA

IN

INDIAN METEOROLOGICAL MEMOIRS, Vol. IV, Part IV, MEMOIR No. VI.

Page.	Number of Cyclone.	Month and Year.	Day.	Line.	For	Read
171	99	November 1886	2nd to 16th	8	85½° E. on the 7th and in lat. 12½° N.	86° E. on the 7th and in lat. 12°-45' N.
"	"	" "	"	9	83½° E.	84° E.
"	"	" "	"	10	28° 80	28° 40
"	"	" "	"	17	15 miles	18 miles.
"	"	" "	"	"	in lat. 14½° N.	in lat. 15½° N.
"	"	" "	"	23	lat. 17° N. and long. 62° E.	lat. 17°-15' N. and long. 62°-45' E.
"	"	" "	"	24	29° 38	29° 24
"	"	" "	"	26	lat. 21½° N. and long. 60° E.	lat. 22½° N. and long. 61°-30' E.
172	100	" "	14th to 24th	14	28° 75	28° 72
"	"	" "	"	22	lat. 16½° N.	lat. 16½° N.
"	"	" "	"	25	29° 03	28° 78
"	"	" "	"	26	28° 7	28° 88

VI.—List and brief account of the South-West Monsoon Storms generated in the Bay of Bengal during the years 1882 to 1886, by JOHN ELIOT, M.A., Officiating Meteorological Reporter to the Government of India.

The present list of storms is a continuation of that given in the VIth paper of the second volume of the Indian Meteorological Memoirs, and was drawn up at the suggestion of Mr. Blanford, Meteorological Reporter to the Government of India. The same definition of a storm has been adopted in drawing up the present list as was employed in compiling the former. The tracks at sea have been laid down from the information obtained from ships arriving at the port of Calcutta. The storms are numbered in continuation of those of the previous list.

A small depression appears to have formed in front of an early advance of monsoon winds up the east of the Bay and near to Diamond Island on the 21st of May 1882. It advanced to Bassein on the 23rd and filled up during the day without advancing further inland. Moderately heavy rain fell in South Burma. Its period of existence appears to have been unusually short on land, and there is no information concerning its formation or intensity at sea. Hence it is not included in the present list of storms. On the 11th, 12th, and 13th of the next month, June, an eddy formed in the immediate neighbourhood of Calcutta, and drifted westward to Hazaribagh on the 14th. On the 16th the centre lay not far south of Benares, and on the 17th between Allahabad and Sutna. It gave remarkably heavy rainfall in Rewah; 22·15 inches fell in 24 hours at Sutna, and 30·45 inches at Rewah. It was a striking example of the land-formed depressions of the rains. This storm is not included in the present list, which hence begins with the storm of July 11th to 16th, 1882.

No.	Year.	Month.*	Day.	Details of Storm. •
47	1882	July .	11th to 16th .	This disturbance formed near the Sandheads on the 11th. The centre crossed the Orissa coast near Chandbally on the afternoon of the 12th, and advanced over Sambalpur on the 13th, and Raipur on the 14th, and on the 15th was near Seoni. It was then commencing to fill up. It disappeared before noon of the 16th. The storm gave heavy rain to the northern and eastern districts of the Central Provinces. In the Bay winds of force 10 were experienced.
48	"	" .	17th to 23rd .	This storm began to form on the evening of the 17th. The centre was almost due south of Saugor Island at 10 A.M. of the 18th. It crossed the coast a little to the west of Saugor Island about noon of the 19th (the depression at that time being '25'). The centre was to the south-west of Hazaribagh at noon of the 20th. It continued to advance in a west-north-westerly direction, passing near Nowgong on the 21st, and through Ajmere on the 22nd, and crossed through Bickaneer beyond the Indus to the neighbourhood of Jacobabad, and either disappeared or advanced into Beluchistan. The depression was neither large in extent nor intense, but was remarkably persistent. It gave heavy rain over the greater portion of its path and also to the Punjab. The strongest winds experienced by ships during its existence in the Bay were of force 11.
49	"	" .	23rd to 26th .	This disturbance originated in the same part of the Bay as the previous. It was smaller and very feeble. Its existence was first indicated on the morning of the 23rd. It crossed the coast near Balasore early on the morning of the 24th, and advanced rapidly in a west-north-westerly direction. The centre was near Sutna on the morning of the 25th, and to the south-east of Ajmere on the 26th. It filled up in Western Rajputana on the evening of the 26th.

No.	Year.	Month.	Day.	Details of Storm.
50	1882	July and August.	31st to 2nd.	This was a very small storm which formed in lat. 20° N. and long. 88° E. on the evening of the 30th. It advanced slightly to the north of west and struck the Orissa coast near False Point on the morning of the 1st, and advanced rapidly into the Central Provinces, where it gave moderate rain and feeble cyclonic circulation of the air on the 2nd and then disappeared.
51	"	August	18th to 24th.	This storm began to form to the south-east of Saugor Island on the evening of the 18th. It crossed the coast to the west of Saugor Island early on the morning of the 20th and advanced very rapidly through Chutia Nagpur. The centre was to the south of Hazaribagh at noon of the 20th, to the south of Benares on the 21st, and near Allahabad on the 22nd. It continued to move to the north-west, but commenced to fill up. The centre was to the south-east of Agra on the 23rd. It disappeared during the next 24 hours in North-East Rajputana. Ships reported winds of force 8 during the storm in the Bay.
52	"	September	6th to 15th.	This storm formed in the east of the Bay in lat. $19\frac{1}{2}^{\circ}$ N. and marched a little to the north of west. Ships leaving the Hooghly experienced winds of hurricane force as soon as they passed into the eastern and southern quadrants. It crossed the South Orissa coast between False Point and Pooree on the morning of the 8th, passed quickly to the neighbourhood of Nagpur on the 9th, and was almost stationary for the next 24 hours, after which it advanced to the north-west to the neighbourhood of Indore on the 13th, then recurved to the north-north-west, and advanced to Neemuch on the 14th. It then curved to the north-north-east and passed through Rajputana to the west of Lahore on the 15th, and disappeared in the north of the Punjab on the 15th. It gave very heavy rain over its path and especially in the Punjab.
53	"	"	13th to 16th.	This was a small storm which was in about lat. 18° N. and long. 87° E. on the 14th and 15th. It advanced west-north-west, and struck the Orissa coast to the south of False Point on the evening of the 15th. It recurved as it crossed the Orissa hills, and proceeded north-north-west through the western districts of Chutia Nagpur, and disappeared during the next 24 hours. The P. V. <i>Cassandra</i> encountered the cyclone on the 15th.
54	"	September and October.	26th to 3rd.	This storm was generated to the west of the Pegu coast on the 26th. It marched in a west-north-westerly direction and struck the coast near False Point on the morning of the 19th. It described a very unusual and prolonged path on land. It first marched to the west-north-west through Chutia Nagpur to the neighbourhood of Satna (where the centre was at 10 a.m. of the 1st October). The centre then recurved to the north, and was a little south of Allahabad on the 2nd. It then drifted eastwards to the neighbourhood of Patna on the 3rd, when it began to fill up. It disappeared before morning of the 4th. The depression nowhere exceeded 28° . The strongest winds experienced in the Bay were of force 9.
55	"	October	12th to 18th.	This storm gave an unusually heavy burst of rain to Orissa, Central and North Bengal, and was the last storm of the year affecting Bengal. It formed in lat. 13° N. and long. 85° E. on the 11th and 12th, and marched north by east to the Orissa coast. The centre was in lat. 16° N. and long. $85\frac{1}{2}^{\circ}$ E. at noon of the 13th, and in lat. 19° N. and long. $86\frac{1}{2}^{\circ}$ E. on the 14th. It crossed the Orissa coast south of False Point on the afternoon of the 14th, and marched northwards along the Orissa plains and parallel to the hills of Orissa during the next 24 hours. The centre was to the west of Balasore at 10 a.m. of the 15th, when it began to curve to the east, and advanced in a north-north-easterly direction to the great bend of the Ganges at Rajmahal, where it was at noon of the 17th, and thence into North Bengal, where it gradually filled up after giving unusually heavy rain on the evening of the 18th. There was no trace of cyclonic circulation on the 19th. Winds of force 10 to 11 were experienced by several vessels in the Bay. A special report of this cyclone has been published in the Meteorological Memoirs, Vol. II, Part II.
56	"	October and November.	26th to 2nd.	This was a comparatively feeble storm, which began to form to the south-west of the Andamans on the 26th. It advanced slowly to the north-west and struck the coast of the Circars to the east of Cocanada late on the evening of the 31st. The depression at the centre probably did not exceed a quarter of an inch. It marched across the East Ghâts into the south-eastern districts of the Central Provinces, and filled up on the 2nd of November.
57	"	November	21st to 26th.	This was generated to the west of the Andamans and Nicobars on the 21st and 22nd. It advanced in a west-north-westerly direction. The centre

No.	Year.	Month.	Day.	Details of Storm.
				crossed the coast midway between Negapatam and Madras on the afternoon of the 24th. It was near Bangalore on the 25th and advanced to the foot of the Ghâts on the 26th. There is no information in the Meteorological Office to show whether it broke up there or marched across the West Ghâts into the Arabian Sea. Squalls "of excessive violence" were experienced by vessels in the Bay of Bengal.
58	1882	November	28th to 30th	This was a smallish storm, which was generated in the same part of the Bay, under the same conditions, and advanced along nearly the same path in the Bay, as the previous storm. It was formed to the west of the Andamans and Nicobars on the 28th, and marched to the west-north-west, and crossed the coast a little to the south of Madras on the morning of the 30th, and disappeared a few hours afterwards. It was followed on the 1st by a small subsidiary depression further north, which advanced to Masulipatam. Winds of force 9 were experienced by ships in the south of the Bay during the storm.
59	1883	June	14th to 19th	This storm formed in the north-west angle of the Bay in the immediate neighbourhood of the coast, and ushered in the monsoon rains. It travelled to the north-west. The centre was near Hazaribagh on the morning of the 15th, and near Gya on the 16th, when it recurved, first to north, and then to east. The centre was near Durbhunga on the 17th, and near Purneah on the 18th, on which day and on the 19th it filled up. It gave very heavy rain to Tirhoot, Bhagulpore, Central and South Behar, on the 17th and 18th.
60	"	June & July	25th to 4th	This was one of the largest and most remarkable storms of the year. It began to form on the evening of the 25th, and drifted at first very slowly westwards. It was near, and to the south of, Saugor Island on the morning of the 29th (when the depression at the centre was about half an inch). The centre was near Sambalpur on the 30th, and to the north-west of Raipur on the 1st July. It continued to advance in a west by north direction over Bhopal on the morning of the 2nd, and Bhuj on the morning of the 3rd. It passed into the Arabian Sea, and the British Indian steamer the <i>Oriental</i> was near its centre in lat. 22° N. and long. 63½° E. on the morning of the 4th, when she experienced winds of hurricane strength (force 12). Vessels in the Bay of Bengal reported winds of intensity up to 11. It gave very heavy rain along the whole belt of its path. It was exceptionally heavy in the Central Provinces and the Berars, bringing a torrent of rain to the hills north of Berar, which flooded the rivers and breached the railways. A special report of this cyclone is given in the Bengal Asiatic Society's Journal, Vol. LHI, Part II.
61	"	July	3rd to 5th	This was a short-lived storm of feeble intensity. It formed to the south of the Mutlah light ship on the evening of the 2nd and morning of the 3rd, and advanced north across the Sunderbunds. The centre was near Jessore on the morning of the 5th. It died out during the afternoon of the 5th. (Ships reported that it blew a hard gale at the head of the Bay.)
62	"	"	6th to 10th	It formed to the south of Saugor Island on the 6th and 7th. The centre advanced westwards across the Orissa coast near Chandbally on the afternoon or evening of the 7th. It marched across the Orissa hills into the Central Provinces, and was midway between Jubulpore and Nagpur on the morning of the 9th. The storm gave moderately heavy rain to the Central Provinces on that day, and gradually disappeared on the evening of the 9th and morning of the 10th. Cyclonic winds of force 10 were experienced by ships in the Bay during its existence there.
63	"	"	12th to 14th	This storm formed on the 12th a little further to the south than the preceding storm. It advanced almost due west, and crossed the Orissa coast on the evening of the 13th, nearly midway between False Point and Gopalpur. It crossed the Eastern Ghâts, and lay over the south-east districts of the Central Provinces on the 14th. It disappeared before the morning of the 15th. The storm was a feeble one, and does not seem to have given rise to winds in the Bay exceeding force 8.
64	"	"	26th to 28th	This was also a comparatively feeble storm. It formed in the immediate neighbourhood of the coast of the Sunderbunds and marched west by north. The centre was a little to the west of Saugor Island on the morning of the 27th. It advanced across Chutia Nagpur, and broke up in the western districts of that area on the evening of the 28th. The strongest winds experienced at sea by ships near the head of the Bay were of force 7 and 8.
65	"	August	22nd to 26th	This small storm began to form on the 22nd August in the north of the Bay, and further south than the previous storms. It was very feeble at sea. The

No.	Year.	Month.	Day.	Details of Storm.
				centre crossed the coast near Gopalpur on the morning of the 25th and advanced to the west by north, and crossed the Eastern Ghâts. Heavy rain fell on that day in the southern districts of the Central Provinces. The storm filled up on the morning of the 26th.
66	1882	November	9th to 14th	This was a remarkable storm, as it is the first storm the path of which has been fully traced which originated in the Gulf of Martaban and passed into the Bay of Bengal. It formed to the south-east of the Andamans in the Andaman Sea on the 9th and 10th. It advanced at first north-west, and was in lat. 13° N. and long. 94° E. on the 11th. It crossed through the Prepara Straits shortly after midnight of the 11th-12th, and was about 120 miles to the west-south-west of Diamond Island on the 12th. It recurved slightly, and was above the same distance to the west-north-west at noon on the 13th. It then began to move more rapidly, first to the north, and then to the north-north-east, and reached the Arakan coast a little to the south of Akyab on the morning of the 14th. The storm broke up shortly afterwards. Winds of hurricane force (10 to 12) were experienced by ships in the north-east of the Bay. A special report of this cyclone was published in the Journal of the Asiatic Society of Bengal, Vol. LIII, Part II.
67	"	November & December.	28th to 7th	This storm followed a very unusual course for the season of the year. Squally weather prevailed in the centre of the Bay from the 27th November, and an imperfectly formed cyclone, with no very definitely marked centre, advanced to the north-west until December 3rd, when it began to be more clearly marked, and recurved to the north-east. The centre was in about lat. $17\frac{1}{2}^{\circ}$ N. and long. 87° E. on the 4th December, in lat. 19° N. and long. 89° E. on the 5th, and in lat. $20\frac{1}{2}^{\circ}$ N. and long. 91° E. on the 6th, when it was approaching the mouth of the Megna. It passed into East Bengal across the Chittagong coast. It was throughout a diffused and ill-defined cyclonic storm. The weather in the Bay during the storm is thus described in the log of the ship <i>Cashmere</i> :— "Weather coming up the Bay (November 29th to December 7th) was a continued succession of terrific squalls, torrents of rain, much thunder and lightning. The winds were variable and light when from the north, but frequently and suddenly veered to south-east and blew furiously. Had a few westerly winds, but only one arched squall from north-west."
68	1884	May	13th to 17th	This storm originated during the first inrush of south-west humid winds into the Bay of Bengal, and immediately antecedent to the establishment of the south-west monsoon. Squally rainy weather prevailed in the south of the Bay from the 9th or 10th. This general disturbance slowly advanced northwards on the 11th, 12th, and 13th, the limit of disturbance on the latter day being probably in lat. 10° N. During the next 24 hours a cyclonic storm was generated, the centre of which was in lat. 11° N. and long. $89\frac{1}{2}^{\circ}$ E. at noon of the 14th. The storm increased rapidly in intensity and moved northwards, gradually recurving to north-east. At noon of the 15th it was in lat. 13° N. and long. 90° E., at noon of the 16th in lat. 15° N. and long. $90^{\circ} 45'$ E., and at noon of the 17th in lat. 16° N. and long. $91\frac{1}{2}^{\circ}$ E. It reached the Arakan coast at 9 p.m. of the 17th, when there was a calm, lasting about 5 minutes, followed by a sudden shift of wind. It broke up during the night of the 17th. The lowest reading of the barometer observed at Akyab was 28.98° . Winds of hurricane force (12) were felt by several vessels which were within 40 to 100 miles from the centre. An account of this storm has been published in the Meteorological Memoirs. Vol. II.
69	"	June	18th to 24th	This was a small whirl, generated near the head of the Bay on the 18th. It advanced slowly westwards across the Orissa coast during the night of the 19th, the centre passing near Chandbally. The centre was north of Cuttack on the morning of the 20th. It advanced rapidly across the Orissa hills into the Central Provinces, and was to the north-west of Sambalpur on the 21st. Heavy rain fell during the day in the northern districts of the Central Provinces. The depression moved northwards on the 22nd, when it was south of Allahabad, to between Allahabad and Lucknow on the 23rd, and then began to fill up and disappeared on the 24th. There were very few ships in the Bay at the time and none near the storm. The strongest winds recorded (in the centre of the Bay) were of force 6.
70	"	June & July	28th to 6th	This storm was formed in the north-west angle of the Bay on the 28th, 29th, and 30th June. It advanced across the Orissa coast between Saugor Island and False Point on the afternoon of July 1st in a north-westerly direction. The centre passed through Chutia Nagpur on the 2nd, and was a little to the south of Benares on the 3rd, and west of Lucknow on the 4th. It advanced as far as Rohilkund on the 5th, and disappeared during the next 24 hours.

No.	Year.	Month.	Day.	Details of Storm.
71	1884	July	9th to 14th	This formed at the head of the Bay on the evening of the 8th or morning of the 9th. It advanced westwards across the Orissa coast north of False Point about midday of the 10th. The centre was close to Sambalpur on the 11th, Jubbulpore on the 12th, and north of Indore (in Malwa) on the 13th. It gave at that time very heavy rain over the Satpuras. It was in Lower-Sind on the morning of the 14th, and either broke up or passed westward beyond India on the afternoon of the 14th. The strongest reported winds at sea were of force 9, but, as in the previous case, very few vessels were near the head of the Bay at the time.
72	"	"	15th to 18th	This was a very small storm (the depression and winds both being feeble). It originated at the head of the Bay on the 15th, and crossed the Orissa coast on the 16th to the south of False Point. It was between Sambalpur and Raipur on the 17th, and appeared to have broken up into two feeble whirls on the 18th, the centre of one lying east of Seoni and the other between Indore and Hoshangabad. Both disappeared before next morning. The strongest winds experienced in the Bay by any vessel were of force 6, but the nearest vessel contributing meteorological logs was in lat. 12° N.
73	"	"	18th to 28th	This was a whirl with a slight barometric depression. It was, however, remarkably persistent. It began to form in Balasore Bay on the 18th, but did not cross the Orissa coast until the afternoon of the 21st. It drifted slowly to the west-north-west and was between Jubbulpore and Sutna on the 25th. It then advanced to the north-west through Bundelkund and Gwalior on the 25th and 27th, and was to the north-west of Agra on the 28th, when it was only traceable by the wind directions of the neighbouring stations. It merged into the depression of Upper India during the day. This storm gave very heavy rain in the Central Provinces, and also, as after effect, on the 29th and 30th excessive local rain fell at and near Umballa, which received 6 inches in 24 hours. The strongest winds recorded during the storm at the head of the Bay were of force 5 to 6.
74	"	August	2nd to 9th	This was also a very small storm, with a very slight barometric depression. It formed off the Balasore coast on the 1st and 2nd, and advanced to the north over Midnapore on the 3rd, and then recurved to the west-north-west and drifted across Chutia Nagpur into the Doab. It was between Benares and Sutna on the 5th, and advanced slowly up the Doab on the 7th and 8th, as a feeble and irregular cyclonic circulation, and finally disappeared in Rohilkhand on the 9th. It gave heavy rainfall to large portions of the Central Provinces and the North-Western Provinces. Winds of force 7 were recorded by a ship near the head of the Bay in lat. 20° N. on the early morning of the 3rd. A small land-formed depression appeared in South-Eastern Bengal on the 3rd September, and marched slowly westwards into Chutia Nagpur on the 6th, after having given very heavy rain to South-West Bengal on the 4th and 5th, and thence through the Central Provinces (to which it gave exceptionally heavy rain), Central India, Kathiwar, and Cutch into the Arabian Sea.
75	"	September	7th to 11th	This was a storm which began to form on the afternoon of the 6th, about midway between Akyab and False Point. It advanced in a west by north direction, and crossed the coast near False Point on the afternoon of the 8th. On the 9th the centre was crossing the Orissa hills, and on the morning of the 10th it was to the north-west of Sambalpur and travelling west-north-west. It gradually became less definite, and the barometric depression disappeared on the 11th. There was slight residual cyclonic circulation for two days afterwards in the Central Provinces.
76	"	September and Oct.	16th to 1st	The first indications of its formation over the Bay of Bengal were given by the change in the winds of False Point and the Northern Circars on the forenoon of the 16th. It seems to have originated over the centre of the Bay, between lat. 16° and 20° N. It was not until the afternoon or evening of the 20th that the centre of the storm crossed the coast between Gopalpur and Vizagapatam, the depression of the barometer being very small and the rainfall accompanying it very moderate. It advanced slowly on a west-north-west course across the country, the rainfall being still moderate, until on the forenoon of the 23rd, when it lay between Nagpur and Chanda. As it approached this position, the rainfall became heavier, 5 inches being registered on that day at Chanda and 3 inches at Nagpur. On the 24th it recurved to the north, passed over the Satpuras, and reached a position between Jubbulpore and Saugor. On the 25th the centre was between Saugor and Jhansi, on the 26th between Jhansi and Agra, after which its further progress was stayed, and it remained virtually stationary up to the end of the month, and, indeed, till the 1st or 2nd of October, causing very heavy rain in Rohilkhand and the Meerut Division of the North-Western Prov.

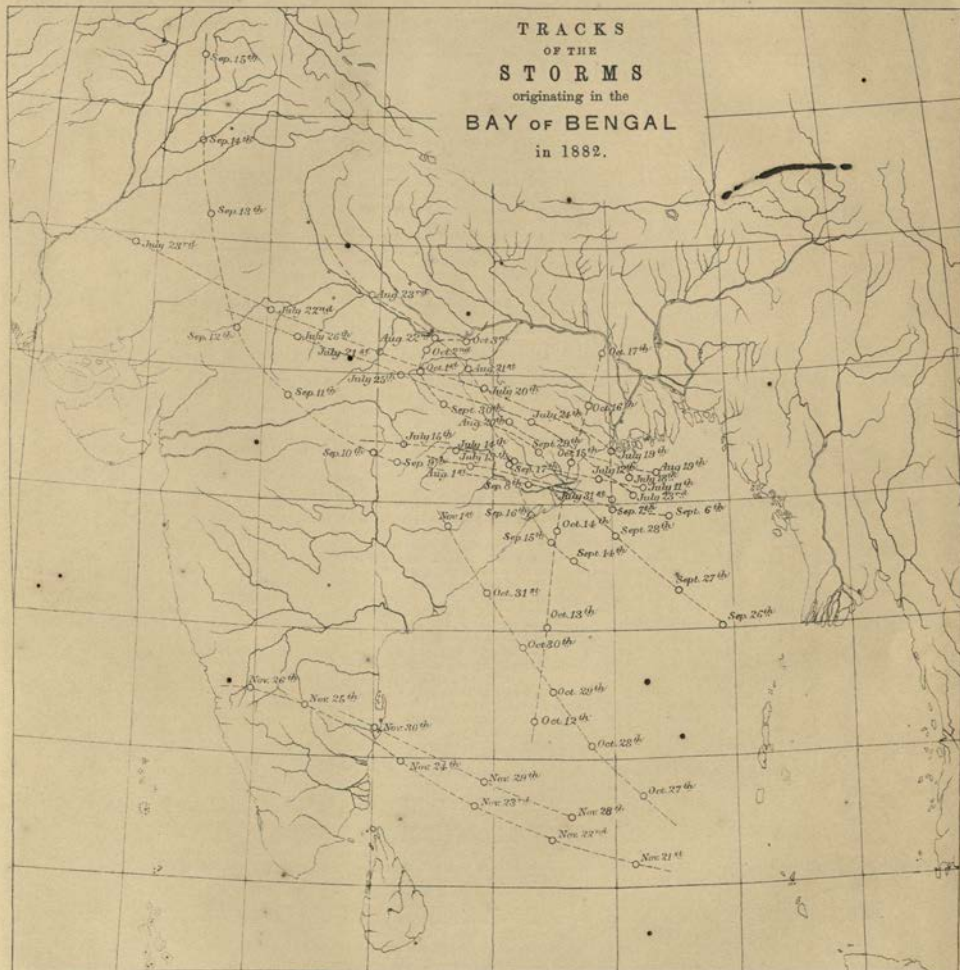
No.	Year.	Month.	Day.	Details of Storm.
				inces. The life of the storm, therefore, exceeded a fortnight and is the longest as yet on record in India. No log has been recorded from any ship which passed through the storm in the Bay, and hence its intensity there is not known.
77	1881	October	15th to 18th	The weather was very squally to the east and north-east of Ceylon on the 14th and 15th, and a small storm appears to have formed on the afternoon of the 15th, the centre of which marched almost due west, and crossed the coast near Negapatam early on the morning of the 17th. The centre was near Madura at 10 A.M. The shift of winds during the next 24 hours appears to indicate that the storm crossed the Peninsula and passed into the Arabian Sea on the night of the 17th. The strength of this storm at sea is not known, as no ship's log throws any light on it.
78	"	"	24th to 26th	This appears to have been an imperfectly formed storm which never had a definite centre. The storm was in about lat. 16° N. and long. 85° E. on the 24th, in lat. 18½° N. and long. 85½° E. on the 25th, and then recurved to the north-east, moving nearly parallel to the coast. It affected the weather in South Bengal to some extent on the 26th, when winds were imperfectly cyclonic. It disappeared during the day. Ships' logs indicate that weather was threatening for two or three days with heavy squalls in the north-west of the Bay, and that from the 26th winds (during squalls) of force 6 to 10 were experienced.
79	"	October and November	29th to 2nd	This was a very small storm, which was encountered at sea by the British India Steam Navigation Company's <i>Khandalla</i> in about lat. 19° N. and long. 90° E. on the 31st. Her log records hurricane winds (force 12) and a mountainous sea. Although she was near the centre, her barometer appears to have fallen less than a tenth of an inch during the storm (allowance being made for the diurnal oscillation). The centre was in lat. 21° N. and long. 90½° E. at 10 A.M. of the 1st November. It apparently crossed the coast between Saugor Island and Chittagong during the night of the 1st, and broke up before 10 A.M. of the 2nd, when there was slight residual cyclonic circulation in Eastern Bengal and Cachar.
80	"	November	3rd to 5th	This storm apparently did not go beyond the earlier stage of storm formation, and never had a definite centre. It originated near the South Madras coast and approached the Tanjore coast, but disappeared before reaching land. It gave very heavy rain in the coast districts of Southern India. No information respecting it is contained in the logs of vessels contributed to the office records.
81	"	"	19th to 21st	No ships (contributing logs) were involved in this cyclonic storm, and hence nothing is known definitely of its origin. It apparently formed on the 18th or 19th nearly midway between Madras and the Andamans, and advanced in a direction west by north, striking the coast near Madras, and a little to the north of it on the morning of the 21st. It was a storm of small extent, but of considerable intensity. It gave a deluge of rain to the coast districts near Madras, which burst the Red Hills tank, the chief reservoir of the Madras water supply. It filled up during the course of the day in the South Deccan.
82	"	December	12th to 19th	This formed to the east of Trincomalee in about long. 83½° E. on the 12th, 13th, and 14th. Cyclonic winds of force 11 were experienced by the <i>Governor Wilmot</i> on the 14th. The storm passed to the north-west and crossed the coast near Negapatam on the early morning of the 18th, and marched rapidly across the south of the Peninsula. It gave much rain to the southern portion of the Peninsula.
83	1885	June	16th to 25th	This formed in the immediate neighbourhood of the coast of the Sunderbunds on the advance of the first great rush of monsoon winds up the Bay into Bengal. Weather was very squally on the 16th (winds of force 8 to 12 were reported by one ship) with strong westerly winds at the head of the Bay. The centre was a little to the south of Jessore at 10 A.M. on the 17th, and between Jessore and Berhampore on the morning of the 18th. It then recurved, and moved almost due west to the neighbourhood of Burdwan on the morning of the 19th. It continued to advance westwards, but merged on the 20th into the general area of low pressure in Chutia Nagpur and the north-east districts of the Central Provinces. A small subsidiary land-formed depression appears to have originated on the 22nd in the trough of low pressure to the west of Saugor Island, and then drifted to the west-north-west on the 23rd, 24th, and 25th across Chutia Nagpur into the eastern districts of the North-Western Provinces, where it disappeared on the evening of the 25th. The track of the latter is not given in the chart, as it did not form in the Bay of Bengal.

No.	Year.	Month.	Day.	Details of Storm.
84	1885	June	25th to 29th	This storm appears to have formed in the immediate neighbourhood of the Balasore coast on the 25th. It advanced to the north-west and passed over Chyebassa on the 27th. The centre was a little to the north of Satna on the morning of the 28th, at which time the storm was giving heavy rain in the south-eastern districts of the North-Western Provinces. It advanced in the same general direction during the next 24 hours, and was a little to the south of Delhi at 10 A.M. of the 29th. Very heavy rain fell in the hills, and neighbouring plain districts of the North-Western Provinces and in the area over which it passed in the Doab. It disappeared during the next 24 hours near the Punjab frontier. Winds of force 7 were experienced at the mouth of the Hooghly.
85	"	July	14th to 17th	This was a very feeble whirl. It apparently began to form on the evening of the 13th. There is no information of it contained in the logs of ships received in the office. It advanced a little to the north of west and crossed the Orissa coast south of False Point on the morning of the 15th, and was near Cuttack at noon. It crossed the hills into the south-eastern districts of the Central Provinces, and was in the Bilaspur district on the morning of the 16th. It disappeared during the next 24 hours after giving moderate rain to the Central Provinces on the 16th and 17th.
86	"	"	23rd to 25th	This was a very feeble storm. It began to form at the head of the Bay on the evening of the 22nd. The centre was to the south-east of Saugor Island at 10 A.M. of the 23rd. It crossed the coast on the evening of the 23rd and advanced rapidly across Chutia Nagpur on the 24th. It was then diffused and irregular, and it disappeared as a cyclone in the course of the evening of the 24th or morning of the 25th. Between the preceding and the next storm a series of depressions formed over South Bengal, which drifted slowly westwards and gave more or less heavy rain to the areas over which they passed during their existence. The most important of these were— 1st.—A whirl which formed to the west of Calcutta on the 2nd August and disappeared within the next 24 hours. 2nd.—A whirl which formed in West Bengal on the evening of the 4th August, the centre of which was between Calcutta and Burdwan on the 5th. It advanced slowly to the north-west across Chutia Nagpur into Behar. The south-west monsoon period of the year 1885 was characterised by the large number of land formed depressions, and by the comparative fewness of sea formed depressions.
87	"	August	15th to 18th	This was a small storm which formed in Balasore Bay on the 15th and 16th of August, and advanced to the west-north-west. It was in the south-western districts of Chutia Nagpur on the 17th, and passed through Bundelkund and Gwalior on the morning of the 18th into Rajputana, where it filled up during the day. It gave moderate rain to the districts over which it passed. Another series of four land formed depressions originated in south-west Bengal during the interval between this and the succeeding storm, drifted generally in a west-north-west direction, and gave moderate to heavy rain to the districts over which they passed.
88	"	September	15th to 17th	This was a very small whirl which formed at the head of the Bay near the Sandheads on the 15th, and advanced west-north-west across the Balasore Coast on the evening of that day, and passed into Chutia Nagpur on the 16th, and after giving moderate rain filled up during the night of the 16-17th. The winds at the head of the Bay, as shown by the logs of the light ships, never exceeded force 6 during the storm.
89	"	"	19th to 25th	This was a storm of small extent, but of remarkable intensity. It was first formed on the morning of the 19th between the Andamans and Diamond Island. It developed slowly at first and advanced in a north-westerly direction about 50 miles during the next 24 hours; after that it intensified with unusual quickness and its velocity increased rapidly. The centre was in lat. $17^{\circ} 30' N.$, long. $89^{\circ} 30' E.$, at noon of the 21st. The centre struck the Orissa coast at False Point about 6 A.M. of the 22nd. The duration of the central calm at the light-house was nearly three quarters of an hour. The barometer fell to 27.435 , the lowest reading on record at the sea-level. The storm wave swept over the low ground near False Point and caused great destruction of life and property. The small station at Hookeytolla was completely swept away. The storm was at that time advancing at the rate of nearly 14 miles an hour, and passed over Cuttack at 8 A.M. The storm recurred slowly after crossing the Orissa hills, and advanced through Chutia Nagpur, and was near Dehree in Shahabad on the morning of the 23rd. It passed into West Behar, but broke up so completely during the next day that no trace of cyclonic circulation was apparent on the morning of the

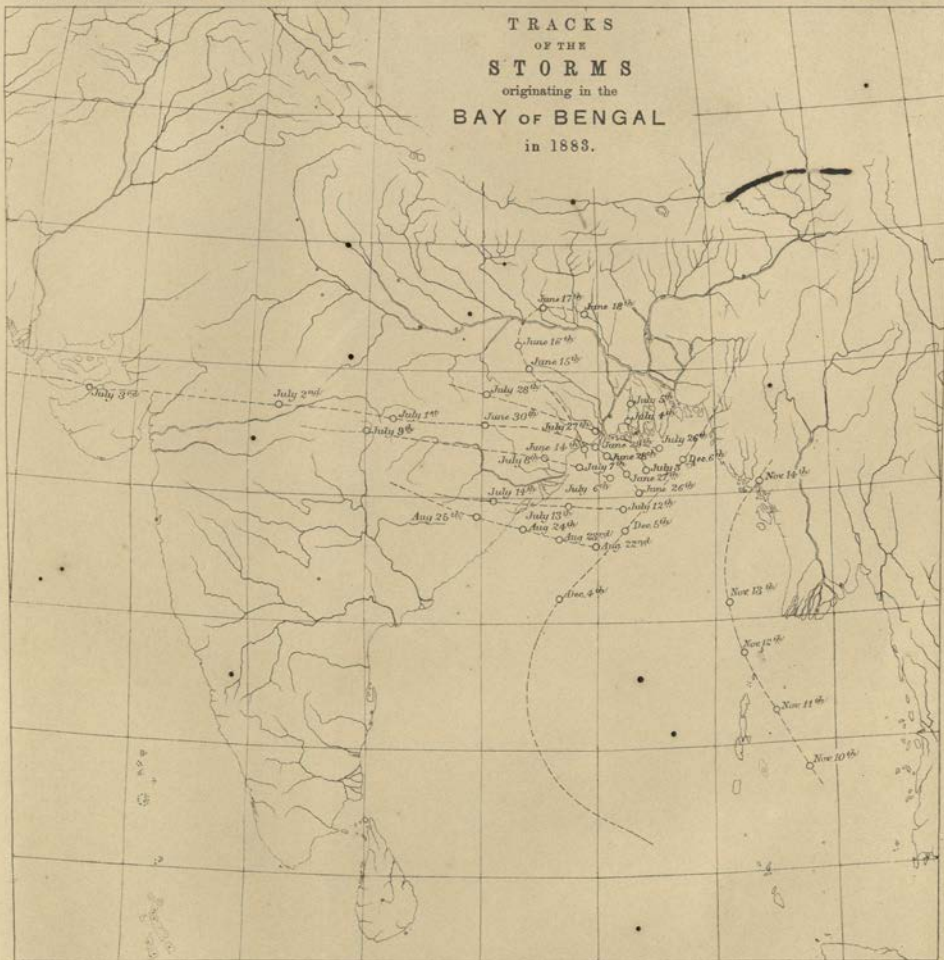
No.	Year.	Month.	Day.	Details of Storm.
				25th. Winds of hurricane force were experienced by vessels in the inner storm area. A full account of this storm, drawn up by Mr. Pedler, has been published in the Indian Meteorological Memoirs, Vol. IV, Part II. There was a marked tendency to cyclonic movement in the Bay during the period October 12th to 14th, and pressure was distinctly lower than in the coast districts. Weather was unsettled with occasional moderate squalls, much lightning and rain, but the very slight depression and irregular cyclonic circulation passed away inland without developing into a storm, and fine weather with light winds set in again on the 25th.
90	1885	November	2nd to 3rd	This was a very small storm which formed near the Coromandel coast on the 1st, and advanced to the west-north-west, crossing the coast to the north of Madras on the early morning of the 3rd. It gave moderate rain during the day and broke up before the morning of the 4th. The <i>Clan Drummond</i> was in the south-west quadrant on the 2nd, and experienced heavy gales and squalls, during which winds were frequently of force 9.
91	"	"	17th to 23rd	This was a remarkable storm, as it apparently formed near the Coromandel coast and advanced to the north-east, parallel to the coast, and finally struck the Chittagong coast, after having marched slowly up the Bay. The logs of ships in the Bay at the time show that it was throughout an imperfectly formed storm. The weather was very squally over nearly the whole of the Bay south of lat. 16° N. on the 17th. Very heavy local rain fell at this period on the South Coromandel coast for a brief time, Negapatam, for example, receiving 14 inches. The storm at first moved very slowly to the north-east, and then gradually accelerated its rate. The centre was apparently in lat. 17° N. and long. 85½° E. at noon of the 21st, and in lat. 19° N. and long. 86½° E. at noon of the 22nd. It struck the coast near Chittagong at about 10 A.M. of the 23rd, and shortly afterwards broke up. During the greater part of its existence winds were very irregular in the Bay, and the strongest squalls and heaviest rain were apparently felt at a considerable distance to the north-east of the centre on the 19th and 20th. Cyclonic winds of force 9, 10, and 11 were experienced by several ships during the latter period of the existence of the storm.
92	1886	May	22nd to 24th	This was a very small and feeble whirl, which formed in about lat. 10½° N. and long. 84° E. on the 22nd, and advanced to the west-north-west and crossed the coast to the south of Negapatam and gave very heavy rain to the southern districts of Madras on the night of the 23rd-24th. It died away during the subsequent 24 hours or more probably passed across the coast of Canara into the Arabian Sea. No information respecting its strength at sea is given by the logs of ships. There was a marked tendency to the formation of a whirl at the Head of the Bay on June 1st, 2nd, and 3rd. It, however, never passed beyond the stage of squally weather and irregular cyclonic winds. Chittagong received 15 inches of rain on the 2nd, and 5 inches on the 3rd. The rainfall was quite local and did not extend to any of the neighbouring observing stations.
93	"	June	14th to 22nd	This storm formed in about lat. 20° N. and long. 89° E. The barometer fell for 48 hours with variable winds at the head of the Bay, whilst a strongish monsoon was blowing further south. The whirl was accompanied with winds of force 9 to 11 on the 15th in the Bay, when it was fully formed, and began to advance to the north-west. It passed over Saugor Island on the 16th and then curved to the west-north-west through Chulia Nagpur, and was to the south of Benares on the 18th, and near Nowgong on the 19th. It advanced rapidly to the west-north-west through East Rajputana, and apparently crossed the Sutlej on the morning of the 21st and advanced to the west of Lahore in a northerly direction through the Punjab and disappeared during the 22nd in the north of the Punjab. It gave heavy rain in Bengal, and very heavy rain over the eastern districts of the North-West Provinces and some parts of the Punjab.
94	"	July	16th to 23rd	This was a very feeble storm during its existence in the Bay. There was almost continuous feeble irregular cyclonic circulation at the head of the Bay from the 17th to the 17th, but it was not till the 17th that a definite and well marked small whirl was formed which began to advance landwards. It moved to the north-west, and crossed the Balasore coast during the night of the 17th. It advanced slowly through the border districts of Chulia Nagpur and the Central Provinces on the 18th, 19th, and 20th, and was between Suta and Jubbulpore on the morning of the 21st. The depression then intensified during the next 24 hours, and advanced through Central India on the 22nd and 23rd into South Rajputana on the 24th, when it broke up. It gave moderately heavy rain to the districts through which it passed.

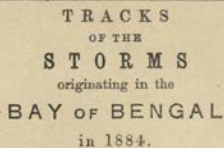
No.	Year.	Month.	Day.	Details of Storm.
95	1886	August	12th to 21st	This was a remarkable storm, as it belongs to a class of rare occurrence. It began to form in the immediate neighbourhood of the coast of the Circars between Masulipatam and Vizagapatam on the 11th, in an area where squalls are of comparatively frequent occurrence during the rains. The depression, although slight on the 12th, was distinctly marked and accompanied by cyclonic motion. The centre was probably not more than 20 miles from the shore. It was in the same position on the 13th, and probably on the 14th, when it was less distinctly marked than on the 12th and 13th. It then began to move to the north-east, and nearly parallel to the coast. It struck the Orissa coast near Pooree on the morning of the 18th, and then recurred rapidly to the west-north-west, passing into the Central Provinces. The centre was nearly midway between Sambalpur and Raipur on the morning of the 19th, and to the south-east of Jubbulpore on the morning of the 20th. The disturbance became more diffused during the day, and continued to advance in the same direction through Bundelkund on the 21st, but disappeared on the 22nd in the area of permanent low pressure at this time in Rajputana and North Sind. It gave heavy rain at sea from the 15th to 19th with frequent squalls. The winds, except during the squalls, do not appear to have exceeded 6 to 8 in force.
96	"	September	18th to 24th	This was a very small whirl which formed in the north-west angle of the Bay on the evening of the 17th. The cyclonic motion was very feeble, and the disturbance remained unaltered in position during the 18th, 19th, and 20th. On the 21st it began to move to the north-northwest, and the centre was at 10 A.M. a short distance to the south-south-east of Balasore. It advanced into Chutia Nagpur on the 22nd and into South Behar on the 23rd, and filled up in North Behar during the next 24 hours. It was a very feeble disturbance throughout and the cyclonic motion not very distinctly developed. It gave heavy rain to Central Behar. The strongest winds recorded at the head of the Bay were of force 7. The weather was squally, but otherwise winds were of very moderate force.
97	"	September and October.	28th to 3rd	The logs of ships show that there was a feeble and irregular cyclonic motion initiated in about lat. 16° N. and long. 90° E. on the 27th. It was equally feeble on the 28th, when the storm commenced to move to the west-north-west. The centre at noon of the 29th was in about lat. 17° N. and long. 83½° E., and was hence near to the coast of the Southern Circars. The disturbance, which was of the same irregular and diffused character as the preceding storm, appears to have crossed the coast during the day. This slight irregular cyclonic motion passed into the Deccan on the 1st of October. The centre was near, and to the south of, Sholapur on the 2nd. It then apparently continued to advance westwards and passed over the Western Ghâts into the Arabian Sea on the morning of the 3rd. Winds of force 7 and squally weather were experienced by ships in the Bay during the storm. From the 5th of October until the 15th an area of slightly diminished pressure lay over near the west coast of the Bay. It was off the coast of Ganjam and Circars from the 5th to the 9th and then travelled slowly outwards along the coast. The lowest pressure was at Masulipatam on the 11th and 12th, and at Madras on the 13th and 14th. It filled up on the 15th. It gave the first burst of north-east monsoon winds and rains to the west coast of the Bay.
98	"	October	16th to 20th	This storm apparently began to form in the centre of the Bay in about lat. 16° N. on the 16th. The centre was in lat. 16° N. and long. 87° E. on the morning of the 17th. It passed over the ship <i>Asia</i> in the afternoon of the 18th in about lat. 16½° N. and long. 84½° E. Her barometer fell to 29.35 at 4 P.M., and the wind blew with cyclonic violence for some time and carried away her mail boat and stay sails. It was of very small extent, as the sky cleared up at 8 P.M., and the wind fell to a calm at midnight. The centre struck the coast a little to the north of Coconada on the morning of the 19th. It gave very heavy rain to the coast districts. It broke up as it crossed the Eastern Ghâts, and the observations of the 20th showed no trace of a depression in the Deccan. There was very feeble residual irregular cyclonic circulation of the air which passed away during the day.
99	"	November	2nd to 16th	This storm was remarkable for its long existence and also for its passing across the South Deccan into the Arabian Sea, to which it gave stormy weather for nearly a week. It began to form on the 1st and 2nd in the immediate neighbourhood of the Andamans and to the west of Little Andaman, the most southern island of the group, and on the 3rd there was a considerable depression and well marked cyclonic circulation. The centre began to move to the west-north-west, but at first very slowly. It was in lat. 11½° N. and long. 88° E. at noon of the 6th; in lat. 12° N. and long. 85½° E. on the 7th, and in lat. 12½° N. and long. 83½° E. on the 8th. It passed over the S. S. <i>Craigton</i> during the afternoon. Her barometer (corrected) stood at 28.80, and the wind blew

No.	Year.	Month.	Day.	Details of storms.
				with hurricane force. The cyclone had developed into one of great intensity and of considerable magnitude, the inner storm (winds exceeding 8 in force) being probably about 200 miles in diameter. The centre struck the Madras coast a little to the north of Madras about 11 A.M. of the 9th. Its rate of motion had gradually increased, and its velocity just before reaching land was between 9 and 10 miles per hour. It advanced more rapidly across the Deccan at the rate of about 15 miles per hour, and was in lat. $14\frac{1}{2}^{\circ}$ N. and long. $75\frac{1}{2}^{\circ}$ E. at noon on the 10th. It crossed the Western Ghats during the afternoon and gave squally weather to the west coast on the 10th and 11th. The storm was at this stage comparatively feeble. It, however, continued to advance in the same direction to the west-north-west and acquired additional energy. It passed over the P. and O. steamer <i>Peshawar</i> on the afternoon and evening of the 13th in about lat. 17° N. and long. 62° E. Her barometer fell to 29.38 at 10-30 P.M., and she experienced terrific squalls of wind of hurricane force, and blinding rain. The centre was at this time recurring to the north. It was probably in about lat. $21\frac{1}{2}^{\circ}$ N. and long. 60° E. at noon of the 15th and was recurring through north-north-east to north-east. It passed over the S. S. <i>Mobile</i> on the evening of the 15th in about lat. $23\frac{1}{2}^{\circ}$ N. and long. 62° E., and she suffered considerably from the force of the gale. She lost 221 horses, 3 boats, and all her awnings, and all the bulwarks were smashed more or less, fore and aft. The storm was then advancing to the Beluchistan coast. A considerable fall of the barometer occurred at Quetta and Kurrachee on the 16th, and unusually strong winds prevailed at these stations until the morning of the 17th. Hence, although there are no materials for tracing the path of the storm later than the evening of the 15th, it is certain it did not completely break up before the morning of the 17th, and probably some hours after it reached the Beluchistan coast. It hence continued as an unbroken cyclonic circulation for at least 15 days.
100	1886	November	14th to 24th	This storm was remarkable, as it is an example of the comparatively rare class of storms which form in the Andaman Sea and pass into the Bay of Bengal. It is also very interesting as contributing evidence to the law that the path of cyclones of the transition period are very largely determined by the influence and position of the land. It travelled first parallel to the Andamans and only adopted the normal west-north-west course after it had advanced to the north of the Andamans, and was approaching the Burmese coast. It formed slowly on the 14th, 15th, and 16th to the south-east of Port Blair at a distance of less than 100 miles. It developed rather rapidly on the 17th and 18th, when it was advancing slowly northwards to the east of the Andamans, and had concentrated into a furious cyclone on the 19th. The ship <i>Airlie</i> was involved in the storm on the 18th and 19th and carried by it through the South Prepara channel. Her barometer (corrected) fell to 28.75 at 5-45 P.M. of the 19th. Her log states that the cyclone blew with fearful force, the squalls were awful, and the rain seemed to come down as in a solid body. The centre passed through the South Prepara channel on the morning of the 19th, and began to recurve, and from the 20th it advanced in an almost due westerly direction. The storm area was of comparatively small extent, probably not more than 100 to 120 miles in diameter at any time during its existence, but within this area the cyclonic action was exceedingly violent. The centre was in lat. 16° N. and long. $90\frac{1}{2}^{\circ}$ E. at noon of the 21st, in lat. $16\frac{1}{2}^{\circ}$ N. and long. $87\frac{1}{2}^{\circ}$ E. on the 22nd, and in lat. 17° N. and long. $84\frac{1}{2}^{\circ}$ E. on the 23rd. It passed over the S. S. <i>Melpomene</i> and <i>Noorjehan</i> on this day. The barometer in the <i>Noorjehan</i> fell to 29.03, and she experienced terrific squalls. The lowest reading of the barometer on board the <i>Melpomene</i> (corrected) was 28.7. She experienced the full weight of the storm, as she became utterly helpless, and was carried with the storm and involved in it for at least 18 hours. The storm centre struck the coast between Cocanada and Vizagapatnam about midnight of the 23rd and gave very strong winds and heavy rain to the coast districts. The storm speedily broke up under the disintegrating action and resistance of the hills, and so completely that on the morning of the 24th there was no trace of cyclonic circulation on the large scale. The storm hence terminated on the early morning of the 24th.
101	"	December	7th to 9th	This storm formed in the south of the Bay and probably in about lat. 9° N. on the 7th after the prevalence of squally weather for several days. The centre advanced to the north-west, and was about 100 miles to the east of Madras at noon of the 9th. It struck the coast some distance to the north of Madras at about 8 P.M. of the same day, and gradually dissipated during the next 24 hours, so that there was hardly a trace of its existence in the wind directions of the 10th. It was somewhat less intense in character than the previous two storms, and more diffused, and strong winds were experienced at distances of 200 to 300 miles from the centre. Thus the <i>Clive</i> had westerly winds of force 10 and hard squalls in lat. $8\frac{1}{2}^{\circ}$ N. and long. $82\frac{1}{2}^{\circ}$ E. on the afternoon of the 8th, when she was upwards of 250 miles from the centre.

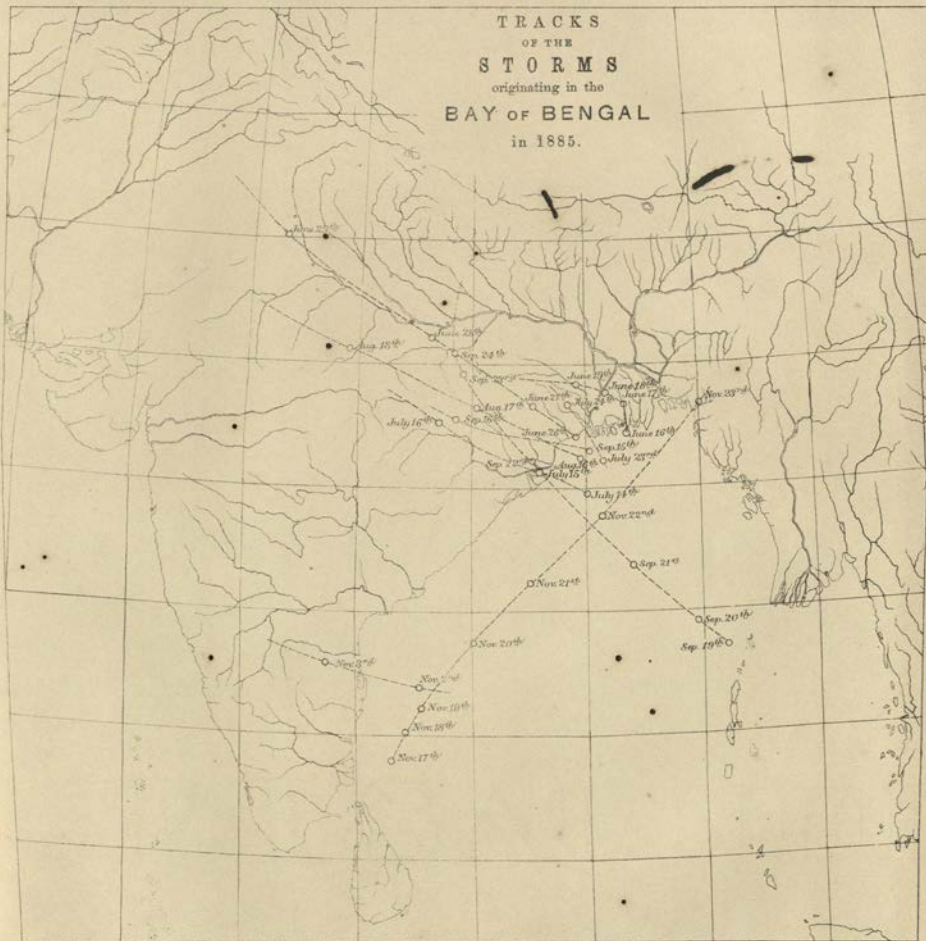


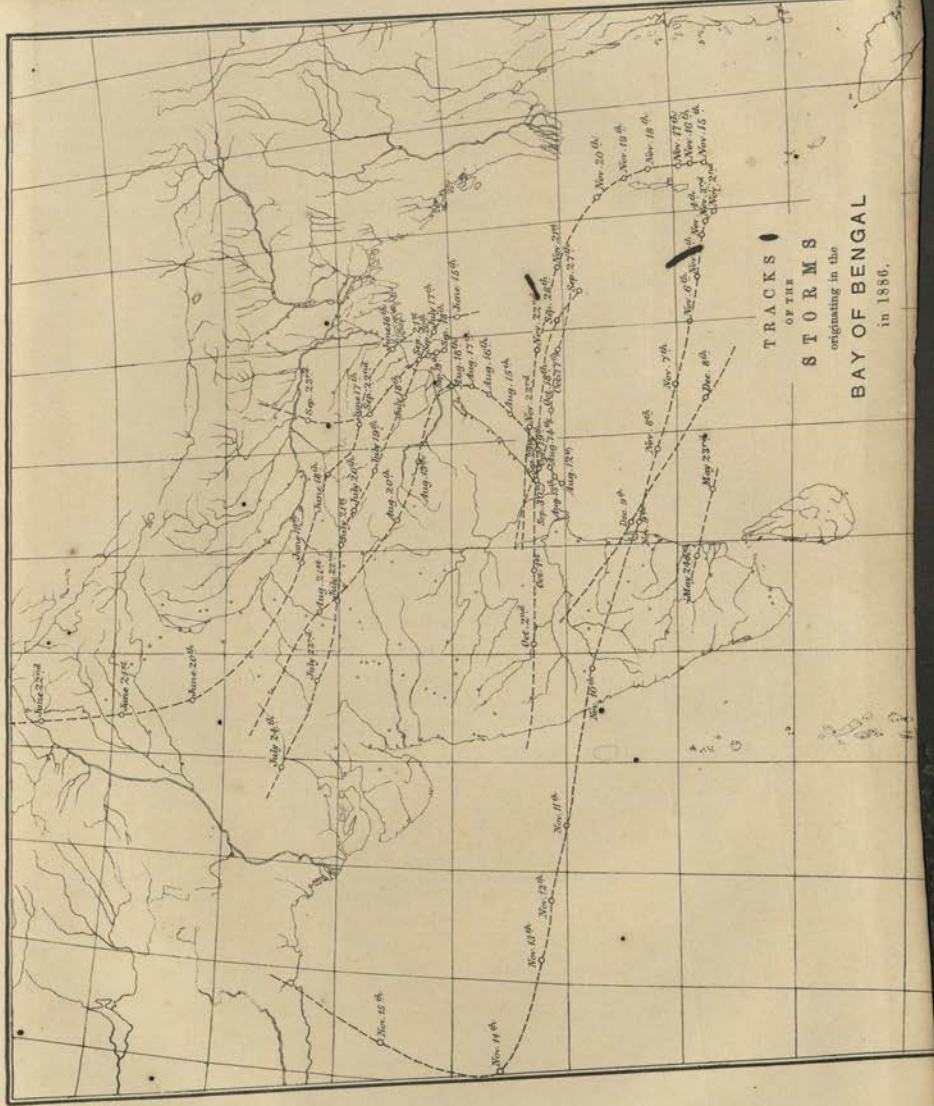
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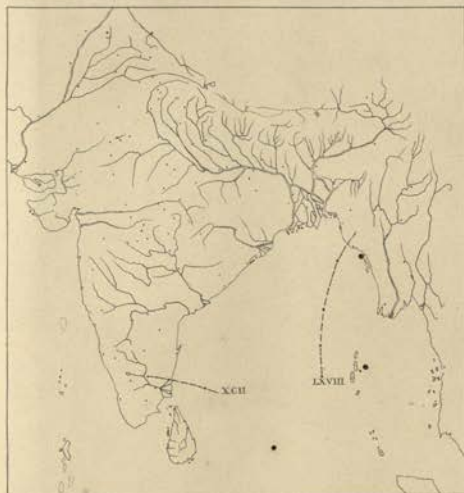


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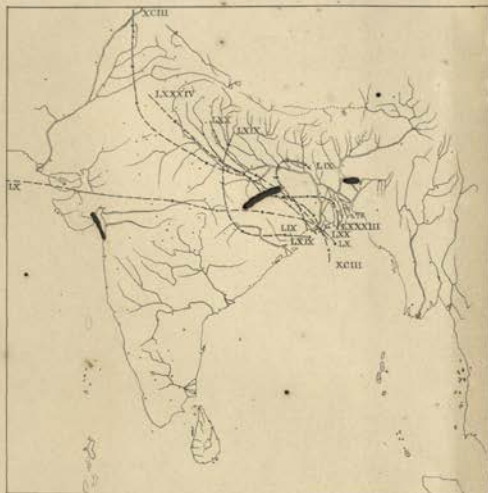




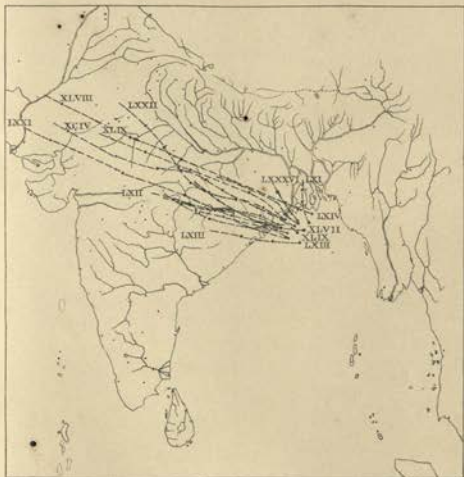
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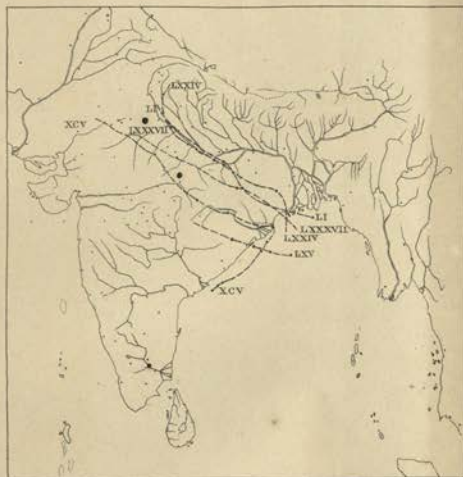
JUNE.



JULY.



AUGUST.



MONTHLY CHARTS OF STORM TRACKS, 1882—86.

*VII.—The cyclonic storms of November and December 1886 in the Bay of Bengal, by
JOHN ELIOT, M.A., Officiating Meteorological Reporter to the Government of
India.*

INTRODUCTION.

The retreat of the south-west monsoon current from Northern India in October 1886 was followed by the occurrence of three cyclones at intervals of about a fortnight, which presented marked peculiarities that appear to make them deserving of investigation and permanent record.

All were generated in the immediate neighbourhood of the Andamans, two of them to the west of the Andamans, the other to the east in the Andaman Sea. The first was a large and violent storm. It began to form on the 2nd and 3rd of November, and moved slowly to the west-north-west. As it approached the Madras coast it increased rapidly in intensity. The barometer at its centre on the 8th stood at 28'4", and winds of hurricane force were experienced by one vessel which was passing up the Bay to the east of the Madras coast. The centre crossed the coast a little to the north of Madras about midday of the 9th. The storm does not appear to have given excessive rainfall to Southern India. It crossed however a narrow part of the Peninsula, and reached the Bombay coast between Ratnagiri and Karwar on the afternoon of the 10th. It was then comparatively feeble. But the logs of ships shew that there had been a tendency to squally rainy weather for some days beforehand in the adjacent parts of the Arabian Sea. The feeble storm centre again drew to itself large supplies of aqueous vapour, and rapidly increased in intensity, and became once more a furious cyclone. It first advanced to the west-north-west until it was in about Lat. 17° N. and Long. 62° E., when it gradually recurved, and finally advanced to the north-north-east to the head of the Arabian Sea. It was off the entrance to the Persian Gulf on the evening of the 15th, when it passed over the steamer *Mobile* in about Lat. 23½° N. and Long. 62° E. It gave strong winds at Kurrachee on the evening of the 15th, and at Quetta on the 16th, so that it evidently did not break up at sea, or even immediately after reaching the Northern or Beluchistan coast of the Arabian Sea. It is, then, an example of a class of storms of occasional occurrence which form in the Bay of Bengal, and pass across Southern India into the Arabian Sea, and have hence a very prolonged existence. Its existence, as a storm, dates from the 2nd to the 16th (at least), and hence extended over a fortnight. It is the first example of its

kind, the history of which has been fully worked out by the Bengal Meteorological Department. The information respecting it which I could obtain is not large in amount, but is sufficient to enable the storm to be traced with approximate accuracy.

The second cyclone was also a very concentrated and violent storm, similar in general character, but of less intensity, than the False Point cyclone of September 1885. It was initiated on the 13th of November, after a brief period of squally weather, a little to the east of the Great Andaman Island. It advanced at first very slowly northward parallel to the Andaman group, and increased rapidly in violence and intensity. The ship *Airlie* was involved in it on the 18th and 19th. When it had passed to the north of the Andamans and up to Lat. $14\frac{1}{2}^{\circ}$ N., it recurved, and adopted the normal course of cyclones generated in the month of November in the Bay, *viz.*, west-north-west. It is thus a remarkable illustration of the effect of the neighbourhood of a mass of land in determining and modifying the path and direction of motion of a large cyclonic disturbance. After recurvature, it advanced across the head of the Bay as a small but well-defined cyclone, the depression at the centre exceeding 1·5 inches. Winds were exceedingly violent at and near the centre, but at a distance of 50 or 60 miles they were comparatively feeble, and little stronger than the normal winds at the season. The storm reached the coast of the Circars to the north of Cocanada about midnight of the 23rd, and was of such small dimensions as to produce hardly any barometric effect at Vizagapatam, which was only 90 miles to the north of the centre on the evening of the 23rd. The country to the west of Cocanada and Vizagapatam is much more broken and elevated than it is further south. The storm appears from the observations to have been disintegrated by the resistance of the hills to its motion early on the morning of the 24th, and was unable to surmount, unbroken, the Eastern Ghâts. The storm is hence interesting for several reasons. It formed in the Andaman Sea and passed out into the Bay of Bengal through the open channel to the north of the Andamans. Although it was apparently as large a disturbance as the preceding, it was unable to surmount the hills of the Eastern Ghâts immediately on reaching land. Hence it did not cross the Peninsula, and pass into the Arabian Sea as the previous storm had done.

The third storm of the series began to form on the 7th of December in the same part of the Bay, and under similar circumstances to the first storm. It was throughout its existence comparatively feeble, and hence, although it travelled across the same part of the Bay, and struck the coast in the immediate neighbourhood of Madras, it filled up rapidly on approaching land, and disappeared a few hours after it crossed the coast in Southern India. This storm was hence in many respects exactly similar to the first. The only apparent difference was the absence of conditions favouring the rapid development and concentration of power and energy. Hence it was comparatively feeble at sea and short-lived on land.

The following pages are devoted to the history of the trio of storms.

Meteorology of India antecedent to the storms of November and December 1886 in the Bay of Bengal.

The history of previous cyclones appears to show that there is some definite relation between cyclone occurrence in the Bay of Bengal and the weather for some weeks if not months, antecedent to their formation. There is a very marked difference

between the number, the line of march, and other characteristics of the storms of one year and of another. The difference is so great as to be only explicable on the same hypothesis as that which is employed to account for the very large and marked differences between the south-west monsoon rainfall of different years. With these large differences in the amount and distribution of rainfall are associated slight but persistent and prolonged variations of pressure, some common to the whole of India, and some local. It requires exact observation and comparison to detect these small variations; but when they have been ascertained they are found, in the great majority of cases, to be generally directly related to the considerable variations in the rainfall of the monsoon period. Whether they are due to variations in the relative strength of the atmospheric currents of the Tropic and Temperate Zones in Asia or to local conditions and actions in India itself and the adjacent seas, is a question which remains to be settled. They may perhaps, in part, be due to the variations of strength in the lower atmospheric currents over Southern Asia and the adjacent seas, and of the range of their influence, and in part to variations in the amount and distribution of the snowfall over the Himalayas.

The following gives a brief sketch of the chief features of the south-west monsoon period of 1886 in Bengal :—

The monsoon rains of 1886 were unusually plentiful in Bengal and Behar. The monsoon was slightly later in being established over the province than usual, and was below its normal strength in June. It gave excessive rain during the months of July and August to the northern and eastern districts of the province (or to North and Central Behar, North and East Bengal), during September and October to South Behar, and in October to Chutia Nagpur. The only districts in which there was a deficiency in the total rainfall of the monsoon period were—Singbhoom, Midnapore, Bankoora, Mymensingh, Backergunge, Rungpore and Jalpaiguri. The deficiency was less than 5 per cent. (or the rainfall practically normal), except in Singbhoom and a portion of Midnapore (represented by the stations of Contai and Tumlook), in which it slightly exceeded 15 per cent. Over the whole of Bengal (with the exception of the districts mentioned above), the monsoon rainfall of 1886 was from 5 to 25 per cent. above the average, the excess, roughly speaking, increasing in amount from east to west and from south to north. It was greatest in the Dacca and Dinagepore districts, for which it was 23 and 22 per cent. respectively. The excess was less marked in Chutia Nagpur and Orissa. In these areas Cuttack and Hazaribagh received the largest excess, the percentage variations for these two districts being 19 and 11 per cent. The most marked feature of the season was the excessive rainfall over the whole of Behar. It was due rather to steady, prolonged downpours, than to occasional violent precipitation, and hence accompanied a continuous determination of the moisture current to that area during the monsoon. It received from 15 to 25 inches above the normal amount. The excess, expressed as a percentage, ranged from 30 per cent. in Chumparun to 59 per cent. in Gya. The districts of Gya, Patna, and Sarun formed the centre of this area of abundant rainfall.

The following five paragraphs describe in brief detail the important features :—

1st.—The monsoon of 1886 was unusually favourable. It gave abundant rain, which lasted until the middle of October in Behar, and until the end of October in Bengal. Its final withdrawal southwards was not followed by the formation of any cyclone entering the province.

2nd.—It was characterized by prolonged periods of general rain rather than by excessive or violent local precipitation. In Bengal, Orissa, and Chutia Nagpur the monthly variations were complementary, slightly deficient rainfall at one period being more than compensated for by excess at another period during the monsoon. In South Behar, and to a less extent in North Behar, the rainfall was excessive throughout the whole season, the Gya, Sarun, and Patna districts apparently forming the centre of an area of favourable abnormal meteorological conditions, and therefore of excessive precipitation.

3rd.—The rainfall in South-West Bengal and Orissa was well distributed throughout the whole season, and was not very excessive in its total amount, in no district except Beerbhoom exceeding the normal by .20 per cent. In East Bengal, the rains were very abundant in the earlier monsoon months, but were deficient towards the end of the rains, especially in October. They were hence not distributed so favourably as in South-West Bengal. The total rainfall of East and North Bengal was either normal or slightly in excess, the greatest excess occurring in the Dacca and Dinagapore districts (23 and 22 per cent. respectively). In Behar the rainfall was more or less in excess throughout the whole season. In Chutia Nagpur it was steadily in defect during the greater part of the rains, the deficiency being greatest in Singbhoom. An unusually heavy fall during the first half of October caused the total rainfall of the period to be slightly in excess in Hazaribagh, Manbhoom, and Lohardugga.

4th.—The following table gives briefly the amount and variation of the rainfall in each of the seven meteorological divisions of the Province, month by month :—

Actual rainfall.

METEOROLOGICAL DIVISIONS.	May.	June.	July.	August.	September.	October.	South-west monsoon period—May to October.
Orissa	4'66	12'10	11'11	9'37	15'75	7'25	60'24
South-West Bengal	7'83	8'94	14'72	11'71	12'48	3'94	59'62
East Bengal	10'30	17'18	19'26	21'38	13'46	3'61	85'19
North Bengal	9'64	12'24	15'13	15'82	22'29	2'74	77'86
North Behar	4'46	6'78	18'80	17'81	13'82	5'31	66'98
South Behar	2'80	7'71	16'05	12'33	16'59	6'74	62'22
Chutia Nagpur	2'97	6'58	11'23	10'82	11'62	8'47	51'69

Variation of actual rainfall from the average in inches.

Orissa	+ 1'07	+ 3'23	— 1'71	— 2'06	+ 5'28	+ 1'12	+ 6'93
South-West Bengal	+ 2'72	— 1'36	+ 2'98	— 1'32	+ 3'58	— 0'54	+ 6'06
East Bengal	+ 0'85	— 1'29	+ 2'91	+ 5'80	+ 1'00	— 2'03	+ 7'24
North Bengal	+ 1'34	— 5'41	+ 0'80	+ 1'77	+ 9'57	— 2'15	+ 5'92
North Behar	+ 1'72	— 1'89	+ 6'56	+ 6'70	+ 4'09	+ 1'91	+ 19'09
South Behar	+ 0'82	+ 0'86	+ 4'12	+ 0'98	+ 9'33	+ 3'64	+ 19'75
Chutia Nagpur	+ 0'56	— 1'89	— 2'28	— 2'68	+ 2'96	+ 5'75	+ 2'42

Variation expressed as a percentage.

METEOROLOGICAL DIVISIONS.	May.	June.	July.	August.	September.	October.	South-west monsoon period—May to October.
Orissa	+ 30	+ 36	— 14	— 19	+ 50	+ 18	+ 13
South-West Bengal	+ 53	— 13	+ 26	— 10	+ 40	— 12	+ 11
East Bengal	+ 9	— 7	+ 18	+ 37	+ 8	— 36	+ 9
North Bengal	+ 16	— 31	+ 6	+ 13	+ 75	— 44	+ 8
North Behar	+ 63	— 22	+ 54	+ 60	+ 42	+ 56	+ 40
South Behar	+ 41	+ 13	+ 35	+ 9	+ 129	+ 117	+ 46
Chutia Nagpur	+ 23	— 22	— 17	— 20	+ 34	+ 211	+ 5

5th.—The rainfall of the south-west monsoon period of the past seven years in Bengal appears to indicate that it follows some cyclical or periodic law. The following table gives the average provincial rainfall for the monsoon period of each of the years 1880-86, and the variation from the average :—

	1880.	1881.	1882.	1883.	1884.	1885.	1886.
Average actual total rainfall, May—October	66.03	63.00	58.51	50.72	52.60	64.90	69.65
Variation from normal average	+ 5.20	+ 2.17	— 2.32	— 10.11	— 8.23	+ 4.07	+ 8.82

The following gives a brief account of the chief features of the south-west monsoon of 1886 over the whole of India.

The dry westerly winds of the hot weather in Northern India continued until the 6th of June, when south-east humid winds advanced from the Bay of Bengal up the Gangetic valley, as far as the Punjab, and caused a large and rapid increase of humidity. A small storm formed at the head of the Bay on the 13th, and advanced north to Calcutta, and then north-west and west as far as Sirsa, and ushered in the monsoon rains over Northern India. The Bombay coast current was weak during the first fortnight and restricted to the southern Provinces. The rainfall of June was slightly in excess except in Northern Bengal, Assam, Burma and the Malabar coast. Similar conditions prevailed during July. The monsoon current brought up fairly abundant rain which was distributed as in the month of June. The rainfall was in excess over the whole of India with the exception of Burma, North Bengal, and some parts of the North-Western Provinces. The variations were nowhere large nor important. A longish break in the rains occurred during the first fortnight of August which extended over nearly the whole of Northern India, with the exception, in fact, of Assam and some parts of Bengal. A storm which formed off the coast of the Circars on the 12th, ushered in another advance of a humid current which gave rain to the whole of Northern India for some days. During the remainder of the month, the rainfall was chiefly confined to those districts under the influence of the Bengal branch of the monsoon current, or to Bengal, Assam, Burma, Behar, and the North-Western Provinces. The rainfall of the month was hence in excess in Bengal, Assam, Behar, Orissa, and the North-Western Provinces to the north of the Ganges, whilst it was more or less in defect

in all other districts except the Carnatic. The deficiency was greatest in the Central Provinces, which barely received one-half of its normal amount. It will thus be seen that the conditions were changing. The Bengal branch of the monsoon current was shewing unusual strength, whilst the Bombay current now became weaker than usual. There was also an unusual determination of rainfall to the coast of Ganjam and the Circars, where there was a slight deficiency of pressure which became more prominent during the next two months.

The conditions which were established during the month of August continued in September. The rains ceased over North-Western India, Rajputana, Central India, Sind, Guzerat in the first week of the month, and the Bombay current gave moderate rain only to the southern districts of that Presidency. The Bengal current supplied abundant rain during the month to Burma, Bengal, Assam, Behar, and the more eastern districts of the North-Western Provinces. The rainfall was especially heavy in Behar, which received nearly three times its normal amount. This determination of heavy rain to South Behar, and the adjacent districts of Chutia Nagpur, was a feature which began to come into prominence during the month of August, and was a very marked feature of the months of September and October. The rainfall of September was hence above the average in those districts depending directly on the Bengal branch of the monsoon current (including the North-Madras Coast districts), and was very deficient in those under the influence of the Bombay branch. The rains ceased in North-Western and Western India in September, and the rainfall of the next month in Northern and Central India was not very large in amount, and due entirely to the Bay of Bengal branch of the south-west monsoon circulation.

The following gives a detailed account of the weather in the Bay and North-Eastern India during the month of October:—

A small depression formed at the commencement of the month, and advanced across the Orissa and Ganjam coast on the evening of the 2nd, and passed through Chutia Nagpur into South Behar, to which it gave excessive rain, and caused very heavy floods in the Sone valley. The depression in Chutia Nagpur and Behar remained almost unaltered in position for upwards of three days, and filled up finally on the 9th.

It has been already pointed out that there had been for some time previously a marked tendency to low pressure on the coasts of Ganjam and the Circars. This became a conspicuous feature in the meteorology of the Bay during the first and second weeks of October. A very slight depression began to form on the 4th off the Ganjam coast, which moved very slowly southwards along the coast, and formed a permanent feature until the 15th, when it filled up and disappeared. There were hence from the 4th to the 9th two depressions depending upon the Bengal monsoon current for their existence, one in Behar, the other off the Ganjam coast. The latter gave occasional rain squalls to the coasts of Bengal and Orissa and in the adjacent part of the Bay. The general disturbance in Bengal accompanying these depressions gave rise to an unusually prolonged series of thunderstorms extending over several days. Thunderstorms with excessive lightning are the chief feature of the small disturbances of the hot weather months. They very rarely occur in Bengal after the rains have commenced. The rains ceased on the 10th of the month in Behar, when the winds changed to their cold-weather directions, and dry, clear weather set in and gradually extended eastwards over Bengal. The depression off the west coast (or over Ganjam and the Circars) occupied practically

the same position from the 4th until the 9th, when it began to move slowly southwards. From the 11th to the 14th, it lay between Masulipatam and Negapatam. It never gave rise to stormy winds or definite cyclonic motion. It however distributed heavy rain over the whole of the west coast districts of the Bay. For example, Cocanada received 6·23 inches on the 9th, Gopalpur 3·1 inches on the 10th, Negapatam 1·90 inches on the 11th and 1·51 inches on the 12th, Masulipatam 2·85 inches on the 13th, Vizagapatam 4·6 inches on the 14th and 3·3 inches on the 15th. The rainfall was however diffused irregularly over a large area, and was not of that concentrated character which invariably accompanies, and is only associated with cyclonic storms in the Bay and Indian area generally.

The weather over the greater part of the Bay during the whole of this period was fine and clear with light winds. In the neighbourhood of the west coast, winds were variable, and were interrupted by occasional squalls with heavy rain. The following are a few of the more characteristic remarks on the weather of this period extracted from the logs of ships :—

“Light breeze and fine during the morning, strong burst of wind, much lightning and thick heavy rain in the afternoon.” “Light breeze and fine, heavy bank of nimbus round to the westward and much vivid lightning to the westward.” “Wind all round the compass with much lightning and torrents of rain. The moon being full, the clouds were visible flying over it with great velocity from south-west, north-east, north, and east, the appearance overhead being very wild.” “Wind from 4 to 5. Rain-squalls during the night.” “Rained heavily during the afternoon. From noon to 4 P.M. winds unsteady.”

These remarks, it may be stated, refer chiefly to the western half of the Bay. Weather was, during the whole of this period, generally fine with passing clouds over the north and north-east of the Bay. The disturbance near the west coast was hence diffused and irregular in character, and did not concentrate into a cyclonic storm during any part of its existence. The indraught to it gave moderately heavy rain to the west coast districts of the Bay, and brought up much cloud into the coast districts of South Bengal and Orissa, which hence received occasional rain showers. With the southward march of the depression, the area affected contracted southwards, and no rain fell in Bengal during the latter stages of its existence. Very shortly after the disappearance of this disturbance, and probably on the afternoon of the 16th, another depression of a different character began to form in the north of the Bay. This gave rise to a cyclonic storm of very small extent, but of considerable intensity. It passed over the S. S. *Asia* on the forenoon of the 18th. The following is the brief account contained in her log :—

“Morning, blinding lightning all round, fresh gale with violent squalls of wind. 10 A.M. wind blowing with cyclonic violence (barometer 29·50”), mail boat and stays blown away. Afternoon, light variable winds with high confused sea.”

This small storm crossed the Ganjam coast on the morning of the 19th, and drifted in a westerly direction into the Central Provinces. It gave heavy rain to the north-west coast of the Bay, and moderate rain to the Central Provinces, Orissa, Chutia Nagpur, and South Behar. The heaviest rainfalls were 6·9 inches at Vizagapatam, 5·3 inches at Bimlipatam, and 3·81 inches at Gopalpur. It filled up on the 20th. A small depression which was apparently subsidiary to it advanced from the north of the Bay into Eastern Bengal, to which it gave moderately heavy rain on the 20th, 21st and 22nd. During this period the continuation of the dry westerly winds of Upper India over Behar, Chutia Nagpur, and

Bengal was suspended, and variable local breezes or humid southerly or easterly winds prevailed over the whole of the Bengal area. A rapid increase of the humidity and temperature of the air hence followed. The disappearance of the depression in East Bengal was however not followed by an immediate return to the normal conditions of the month. The barometer fell in Upper India, and the westerly winds down the Gangetic valley either became very feeble or were replaced by local airs. Hence light local winds continued in Behar and Bengal. The excessive temperature produced no sensible effect on the horizontal motion of the air for some days, but gave rise to large and rapid oscillations of the barometer. A feeble influx of sea winds followed, and the atmosphere became slightly disturbed. Frequent thunderstorms occurred in the coast districts, and an unusually high temperature prevailed over the whole of the interior as far west as Behar and the North-Western Provinces. These abnormal conditions in Bengal lasted until the end of the month, when they passed away, and were replaced by the normal cold weather conditions of November.

During this period, *i.e.*, from the 21st to the end of the month, occasional showers also fell in Burma, the Bay Islands, the Central Provinces, and over the greater part of the Deccan, and in the west coast districts of the Bay, where the largest amounts were registered. The differences of pressure were very small. On one or two occasions a very slight depression appeared on the Coromandel coast, but it passed away in less than 24 hours. Light variable winds prevailed in the Bay. The skies were generally clear, but occasional squalls with rain occurred. The following extract from the log of the ship *Colaba* is a typical example of the general character of the weather as experienced by vessels navigating the Bay at this time:—

Month.	Date.	Hour.	WIND.		Weather during the day.
			Direction.	Force.	
October 1886.	28th	4 A.M.	Var.	4	Hazy and rainy appearance.
		8 A.M.	NE	2	Fine and clear.
		Noon	NNE	4	Cloudy.
		4 P.M.	Var.	5	Fine.
		8 P.M.	NE	5	Fine and clear.
		Midnight		4	Fine and clear.
Position at noon $13^{\circ} 38' N. 81^{\circ} 52' E.$					
"	29th	4 A.M.	NE	5	Fine and clear.
		8 A.M.	"	4	Fine and passing clouds.
		Noon	"	2	Fine and clear.
		4 P.M.	"	2	Fine and clear.
		8 P.M.	"	2	Fine and clear.
Position at noon $15^{\circ} 13' N. 81^{\circ} 22' E.$					

It has thus been seen that the meteorology of the month of October was very abnormal. The unusual strength of the Bay of Bengal monsoon current in this month was

shewn by the formation of a number of small cyclonic disturbances or whirls near the head of the Bay, which advanced and crossed into Chutia Nagpur, Behar, and the Central Provinces. Although they did not give rise to violent winds or stormy weather at sea, they brought up much rain into the interior, and hence Behar, the North-Western Provinces, Central India, South Bengal, Orissa, Chutia Nagpur, and the Central Provinces received rainfalls considerably in excess of their normal amounts. During the greater part of the month, the low pressure which had characterized the Carnatic coast during the month of September, became intensified, and there was thus a steady determination of the monsoon current during the first fortnight of October to the west coast, which gave moderately heavy rain over it and the adjacent districts in the interior. Hence the Carnatic and the greater part of the Deccan received normal or excessive amounts.

The whole of India with the exception of Northern Bengal and Assam, and some parts of Southern India, thus received larger amounts of rain than usual in October. This, it should be carefully noted, was due to the unusual strength of the Bay of Bengal current. A large portion accompanied a series of storms or depressions which were of a different character to those that usually occur in October, but similar to those which form in September before the south-west monsoon current has finally retreated from Northern India. The barometric depression at their centre was small, and the winds were comparatively feeble. They nevertheless gave heavy rainfall to large areas, and surmounted the Orissa hills and Eastern Ghâts unbroken, and were hence cyclonic storms of high elevation.

Again the area of low pressure over the west coast of the Bay in the first half of the month was a large ill-defined area, but the moisture current was drawn more and more to it as it retreated from Bengal. Rainfall occurred over this area much in the same manner as during the rains in Northern India. Light to moderate showers occurred daily in the coast districts, the area of low pressure moved irregularly along the coast with the rainfall, but there was no tendency to concentration, and no localized heavy rainfall. After some days of this diffused and irregular disturbance and rainfall, pressure began to increase and rainfall diminished and became more irregular, and after the 15th of the month it was small in amount, and the usual conditions accompanying almost entire cessation of rainfall during the October transition period were gradually established and were very marked at the end of the month. These conditions (as stated in previous cyclone reports) are :—

- (1) Approximately uniform pressure over the whole of the Bay and also of the Indian land area.
- (2) Approximate uniformity of temperature and humidity conditions in the Bay area and adjacent coast districts.
- (3) The prevalence of light unsteady winds over the north and centre of the Bay, and if the break be very pronounced, over the whole of the Bay.

The weather in the Bay under such circumstances is fine, skies clear, and sea smooth. The meteorological observations of the 1st November will show how far these conditions were established.

CHAPTER III.

HISTORY OF THE THREE CYCLONES OF NOVEMBER AND DECEMBER 1886.

The preceding chapter has given a brief account of the weather during the month of October. It has shewn that the Bengal branch of the monsoon current had been during the earlier part of the month unusually strong, and had brought up large supplies of aqueous vapour. During the first three weeks of the month of October there had been a series of small depressions formed, the majority of which were similar in character to those of the rains proper. This period of slightly disturbed weather was followed by ten days of fine weather with passing clouds, and occasional showers over the whole of Central and Southern India, Burma, and Soath Bengal, and to a less extent in the Bay itself. Conditions began to change at the end of the month. Pressure increased rapidly in the Punjab, the westerly winds down the Gangetic Valley strengthened and extended eastwards into Behar, and cold weather conditions were established on the evening of the 31st over the whole of Northern India.

The history of the three storms may hence be conveniently taken up from this point, when apparently the normal conditions and weather proper to the season were established after a period of prolonged but diffused rainfall.

1ST NOVEMBER.

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M. corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29.946	+008	+002	85.0	76	ESE	2	42	...
Port Blair . . .	29.911	+030	-027	86.7	79	ESE	8	103	...
Diamond Island . . .	29.986	P	+027	80.4	80	ESE	P	P	1.15
Rangoon . . .	29.981	+023	+007	83.6	84	ESE	2	47	1.03
Akyab . . .	29.991	+043	+034	79.0	84	ESE	4	182	0.18
Chittagong . . .	30.003	+043	+061	78.7	83	NE	1	31	...
Calcutta . . .	29.998	+045	+030	81.4	77	NE	1	34	...
Saugor Island . . .	30.015	+058	+050	81.4	74	NE	4	63	...
False Point . . .	30.000	+066	+032	84.3	72	NE	5	82	...
Gopalpur . . .	29.984	+037	+023	86.6	71	Calm	1	13	...
Vizagapatam . . .	29.985	+046	+021	84.0	72	NE	0	0	...
Cocanada . . .	29.968	+014	P	81.5	83	NE	4	P	...
Masulipatam . . .	29.943	+001	-013	86.1	70	E	3	51	...
Madras . . .	29.948	-005	-015	88.0	69	NE	3	43	0.08

STATIONS.	Barometer at 10 A.M. corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	Wind.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Negapatam . . .	29'934	+020	-018	83'9.	76	NE	4	77	0'08
Trincomalee . . .	29'904	+004	-020	83'5	81	E	6	90	0'03
Galle . . .	29'909	-016	-029	80'0	91	NW	6	167	0'06
Nagpur . . .	29'978	4'037	-017	82'7	63	NNE	4	148	0.50
Bombay . . .	29'933	+005	-043	85'0	76	ENE	8	81	...
Patna . . .	30'030	+059	+038	80'6	61	SE	1	67	...
Allahabad . . .	30'019	+041	+021	80'7	56	Calm	1	83	...
Lahore . . .	29'998	+042	+009	76'7	33	S	1	71	...

The barometer had risen rather rapidly during the preceding 24 hours in Northern and Central India, and over the north of the Bay, and was either stationary or had fallen slightly in Southern India, Ceylon, and over the south of the Bay. Pressure ranged from about 30'03" in Rajputana and the North-Western Provinces to 29'91" at Port Blair and Galle, and 29'92" at Colombo. The gradients were hence small, but such as obtain during the north-east monsoon. Calms prevailed at an unusually large number of stations in the Gangetic plain as far east as Benares. North-easterly winds were blowing at the majority of stations in Bengal, and north-easterly to easterly winds over the greater part of the Bay, but they were considerably below their normal November strength. Temperature was above the average, but was falling rapidly. The air was also damper than usual over the whole of Northern India, with the exception of the Punjab and adjacent districts. No rain fell except in the most southern districts of the Madras Presidency, including the Madura, Coimbatore, and Negapatam districts, and in Mysore and South Burma. The showers were very light. The preceding day had been rainless at Port Blair or Nancowry, and the weather at these stations at 10 A.M. was fine with passing clouds. It should be noted that the Port Blair and Nancowry observations are not very reliable. These stations have been very rarely inspected, and the observers occasionally fall into the habit of taking the observations carelessly. An examination of the observations of the months of October, November, and December 1886 discloses a large number of erroneous readings, some of which appear to be due to faulty adjustment of the vernier. It is very doubtful, for example, whether the reading of the 1st at Port Blair is correct.

Noon observations taken on board ships in the Bay of Bengal and Arabian Sea.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Craigton</i> . . .	8° 8'	73° 56'	30'32	29'92	Var.	...	8 A.M., light showers; noon, light airs; midnight, dark gloomy weather, much lightning.
<i>Ballaarat</i> . . .	9° 38'	64° 4'	30'02	29'89	Var.	2	4 A.M., cloudy; 8 A.M., squally; 4 P.M., drizzling rain; midnight, cloudy.
<i>Colaba</i> . . .	18° 29'	84° 48'	29'98	29'99	N.E.	2	Fine and hazy.

The preceding ship observations are very few in number. They however indicate one fact of considerable importance. The *Ballaarat* and *Craigton* were between the Maldives and Laccadives, and hence passing through the open sea to the west of Ceylon and the west-south-west of Southern India. The weather there was somewhat unsettled. Rain occurred at intervals, and the weather was more or less squally; the winds were light and very variable. Hence it appears that the humid south-west monsoon current extended northwards as far at least as Lat. 10° N. at this time, and was of sufficient volume to feed into any cyclonic disturbance that might be generated in that area, or might pass into it from the Bay of Bengal.

2ND NOVEMBER.

10 A.M. observations (chiefly at coast stations).

STATION.	Barometer at 10 A.M. corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29'910	—'036	—'034	80'4	80	ESE	3	62	1'10
Port Blair . . .	29'898	—'013	—'040	82'2	81	ESE	10	130	0'68
Diamond Island . . .	29'980	—'006	+ '020	81'4	83	ENE	9	106	0'04
Rangoon . . .	30'000	+ '019	+ '025	82'6	80	NE	5	116	0'01
Akyab . . .	30'015	+ '024	+ '055	82'1	79	NNE	3	136	0'90
Chittagong . . .	30'014	+ '011	+ '035	78'2	73	NE	1	31	...
Calcutta . . .	30'031	+ '033	+ '066	84'9	72	ENE	2	69	...
Saugor Island . . .	30'031	+ '016	+ '050	81'4	74	ENE	4	63	...
False Point . . .	30'012	+ '012	+ '036	84'3	75	NNE	7	115	...
Gopalpur . . .	30'006	+ '022	+ '041	86'6	68	Calm	3	39	...
Vizagapatam . . .	29'975	—'010	+ '007	84'0	70	N	1	38	...
Cocanada . . .	29'975	+ '007	?	82'5	75	NE	11	?	0'06
Masulipatam . . .	29'951	+ '008	—'008	86'6	69	NE	6	102	...
Madras . . .	29'977	+ '029	+ '012	79'2	89	Calm	6	87	1'20
Negapatam . . .	29'930	—'004	—'023	83'4	84	NE	4	77	0'09
Trincomalee . . .	29'907	+ '003	—'017	80'0	87	W	6	90	0'51
Nagpur . . .	30'002	+ '024	+ '003	83'2	59	E	5	185	...
Bombay . . .	29'958	+ '025	—'020	86'5	65	ENE	8	81	...
Patna . . .	30'057	+ '027	+ '061	81'6	47	SE	1	67	...
Allahabad . . .	30'061	+ '042	+ '065	81'8	43	SSE	1	83	...
Lahore . . .	30'022	+ '024	+ '028	79'7	32	S	2	143	...

A further rise of the barometer had occurred during the preceding 24 hours over the whole of Northern and Central India, and the north and centre of the Bay. The barometer was steady in the south-west of the Bay, but was commencing to fall at Nancowry and Port Blair. Rain had also fallen there in moderate amounts, but no

change of wind direction was shown until the evening. The observations indicate that there was now an area of slightly diminished pressure to the west of the Andamans and north-west of the Nicobars, in which pressure was nearly two-tenths of an inch lower than in the Punjab and Northern India generally. It was however only '03" below the average pressure of the month, and hence practically normal. Winds were very light over the greater part of India, and were unchanged in direction. They were however increasing in strength at Port Blair, Diamond Island, and in Burma and Arakan generally. Rain fell in larger amounts in Southern India than on the previous day. It ceased to fall for a time in Burma, and was hence now confined solely to the most southern districts of the Madras Presidency, where it was apparently brought up by westerly winds from the Arabian Sea, as the largest amounts were recorded on and near the Malabar coast at Cochin (2'46 inches), Wellington (1'64 inches), and Coimbatore (1'52 inches).

Noon observations taken on board ships in the Bay of Bengal and Arabian Sea.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Craigton</i>	7° 14'	76° 56'	30°35	29°95	Var.	1	Morning, dark gloomy weather, lightning and rain; noon, dark and gloomy weather; midnight, rain.
<i>Ballaarat</i>	8° 48'	69° 8'	30°08	29°95	ENE	3	4 A.M., cloudy and overcast sky; 8 A.M., fine; noon, fine cloudy weather; midnight, vivid lightning to S.
<i>Colaba</i>	20° 30'	87° 37'	29°98	29°99	NE	4	Fine and clear. 8 P.M., weather squally with rain; midnight, fine and hazy.
<i>Clan Buchanan</i>	Left Saugor at noon.	...	29°84	30°00	NE	3	Squally at intervals.

The observations recorded in the logs of the *Ballaarat* and *Craigton* show that weather was unchanged to the west of Ceylon. Dark gloomy weather with light variable winds, occasional showers, and much distant lightning were its chief features. Weather was slightly unsettled at the head of the Bay. The *Colaba* and *Clan Buchanan* had light squalls in the afternoon and evening with some rain.

3RD NOVEMBER.

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours, preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry	29°924	+°014	—°020	81°0	87	SW	6	126	0°75
Port Blair	29°814	—°084	—°125	82°7	79	ENE	11	155	0°30
Diamond Island	29°977	—°003	+°016	82°9	75	ENE	11	129	...
Rangoon	29°998	—°002	+°022	81°6	77	ENE	5	116	...
Akyab	30°014	—°001	+°051	83°1	70	NE	2	91	...
Chittagong	30°031	+°017	+°068	78°2	74	Calm	1	31	...

STATIONS.	Barometer at 10 A.M., corrected and reduced to 31" and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND			Rainfall during 24 hours, preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Calcutta . . .	30.044	+0.013	+0.077	79.5	54	NE	4	138	...
Saugor Island . .	30.049	+0.018	+0.057	79.4	70	NE	7	111	...
False Point . . .	30.028	+0.016	+0.034	84.3	68	NE	9	148	...
Gopalpur . . .	30.023	+0.017	+0.054	86.6	64	NE	6	79	0.15
Vizagapatam . . .	30.005	+0.030	+0.033	84.5	62	N	2	77	...
Cocanada . . .	29.996	+0.021	P *	82.0	77	NE	12	?	...
Masulipatam . . .	29.963	+0.012	+0.001	85.6	66	NE	8	136	...
Madras . . .	29.952	-0.025	-0.015	87.0	69	NNE	5	72	0.70
Negapatam . . .	29.934	+0.004	-0.020	79.9	90	NE	5	96	0.81
Trincomalee . . .	29.907	0	-0.018	76.0	95	SW	5	75	1.61
Galle . . .	29.953	?	+0.015	77.0	95	W	10	278	1.32
Nagpur . . .	30.029	+0.027	+0.026	82.2	54	ENE	6	222	...
Bombay . . .	29.979	+0.021	-0.001	86.0	63	ENE	8	81	...
Patna . . .	30.087	+0.030	+0.081	79.6	54	S	1	67	...
Allahabad . . .	30.071	+0.010	+0.069	79.7	49	SW	1	83	...
Lahore . . .	30.057	+0.035	+0.058	76.7	42	Calm	1	71	...

The 10 A.M. observations of the 3rd indicate that pressure had increased over the whole of the Indian land area by nearly equal amounts, and hence the distribution of pressure was unaltered. A further fall had however occurred at Port Blair and the neighbouring stations. It was only large in amount at Port Blair, and the chart of the day shews that the depression of the preceding day had developed and concentrated considerably. The winds had also shifted in direction over the south of the Bay. They were at 10 A.M. from south-west at Nancowry and from east-north-east at Port Blair, and thus indicate that cyclonic indraught was now fully established in the area of depression. The air motion was also increasing rapidly in intensity over the south and south-east of the Bay, and winds were considerably above their normal strength, more especially at Galle and Port Blair. It may be fairly assumed from these facts that the barometric depression which developed into the cyclonic storm was restricted on the 1st and 2nd to the west and west-south-west of the Andamans, and that cyclonic motion of the air was fully established over a considerable portion of the Bay between the Andamans and Nicobars and the Coromandel coast on the evening of the 2nd and morning of the 3rd.

The winds in Upper India also strengthened at this time, but this was evidently due to the continuance of high pressure and cold weather conditions in Upper India.

No rain fell in India on this day except at Port Blair and Nancowry, and also in Ceylon and the more southern districts of Madras, and was, as on the previous day, mainly, if not entirely, due to westerly winds bringing up moisture from the South Arabian Sea. The

largest amount recorded was 2·2 inches at Tranquebar. Moderate rain fell during the day at Port Blair and Nancowry.

Noon observations taken on board ships in the Bay of Bengal and Arabian Sea.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Craigton</i> . . .	6° 0'	79° 56'	30·35	29·95	Var.	1	4 A.M., rain; noon, constant heavy rain and squally weather; midnight, variable airs, cloudy.
<i>Ballaarat</i> . . .	7° 59'	74° 30'	30·07	29·94	E	2	8 A.M., heavy rain; afternoon, overcast with rain.
<i>Clan Buchanan</i> .	15° 0'	82° 24'	29·76	29·92	NE	4	Sea smooth; weather clear.
<i>Colaba</i> . . .	River Hooghly.		29·99	30·00	NNE	4	Fine and hazy.

These observations confirm the conclusion derived from those of the 1st and 2nd, that in the Arabian Sea to the west of the Ceylon and Travancore coasts, the weather was unsettled and squally, and much rain was falling. Weather was fine and clear with moderate north-east winds in the north-west of the Bay.

4TH NOVEMBER.

10 A.M. observations (chiefly at coast stations).

STATIONS	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29·920	—·004	—·024	82·4	85	SW	4	78	0·98
Port Blair . . .	29·810	—·004	—·129	82·2	88	SE	13	174	1·30
Diamond Island . . .	29·972	—·005	+·010	78·4	89	ENE	14	165	0·33
Rangoon . . .	29·984	—·014	+·007	79·6	88	ENE	5	116	...
Akyab . . .	30·002	—·012	+·036	85·2	71	NNE	2	91	...
Chittagong . . .	30·008	—·023	+·043	80·2	77	NE	1	31	...
Calcutta . . .	30·043	—·001	+·075	78·0	60	N	4	138	...
Saugor Island . . .	30·044	—·005	+·046	78·4	61	NNE	8	127	...
False Point . . .	30·036	+·008	+·040	81·3	65	NNE	10	164	...
Gopalpur . . .	30·027	+·004	+·054	85·6	57	NNE	8	105	...
Vizagapatam . . .	30·006	+·001	+·030	83·0	57	NE	3	115	...
Cocanada . . .	29·990	—·006	?	81·5	65	NE	15	?	...
Masulipatam . . .	29·974	+·011	+·009	83·6	65	N	6	102	...
Madras . . .	29·985	+·033	+·016	75·0	93	NNW	9	130	2·69
Negapatam . . .	29·963	+·029	+·008	75·3	97	NNE	5	96	4·33
Trincomalee . . .	29·942	+·035	+·016	78·5	91	W	4	60	0·16

STATIONS.	Barometer at 10 A.M., corrected and reduced to 30" and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Galle	29'949	—'004	+ '011	80'0	91	N	7	194	0'09
Nagpur	30'071	+ '042	+ '064	79'7	43	ENE	5	185	...
Bombay	30'000	+ '021	+ '018	85'5	58	ENE	10	101	...
Patna	30'092	+ '005	+ '073	78'5	51	ENE	1	67	...
Allahabad	30'098	+ '027	+ '089	78'2	39	W	1	83	...
Lahore	30'040	—'017	+ '036	72'6	46	Calm	1	71	...

The preceding observations shew that the barometer fell over the east and north of the Bay, and rose over nearly the whole of India. The changes were, however, small in all cases. Pressure was very uniform over the whole of Northern India, as is usual in October and the first half of November. The area of highest pressure at this time stretched from Assam through North Bengal, the North-Western Provinces and Rajputana into Sind.

The chart of the day indicates that the depression was in the same position as on the 3rd. The winds at Port Blair, Diamond Island, and Nancowry shew more extended cyclonic motion than on the 2nd or 3rd, and also indicate by their direction and force that the depression was greater than on the 3rd. Rain continued to fall in moderate amounts in the Bay Islands. No rain fell in any part of India except the most southern districts, evidently due to the same general cause as on the previous days, *viz.*, the presence of a humid current advancing in an easterly direction from the adjacent portion of the Arabian Sea.

The largest amounts were recorded on the 4th in the Coromandel Coast districts:—Negapatam received 5'53 inches, Cuddalore 4'75 inches, Tranquebar 3'9 inches, and Madras 2'67 inches.

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Craigton</i> . . .	5° 50'	81° 30'	30'35	29'95	Var.	1	Dark gloomy weather; showery; much lightning.
<i>Ballaarat</i> . . .	7° 1'	79° 32'	30'07	29'94	E	2	Squally, with rain.
<i>Akbar</i>	12° 49'	94° 10'	?	?	SSW	?	4 P.M., strong wind and heavy rain; 8 P.M., strong wind and heavy rain squalls; 9-45 P.M., split the jib during a heavy squall.
<i>Clan Buchanan</i> .	17° 19'	84° 27'	29'81	29'97	NE	4	Fine clear weather; sea smooth.

The observations taken on board the *Ballaarat* establish that no change had occurred in the weather in the Arabian Sea to the west of Ceylon. The S. S. *Akbar*, which left Rangoon on the 2nd, and was proceeding westwards to Bombay, was to the east of the Andamans on this day, and experienced strong winds, severe squalls, and rough weather.

The observations are so few in number, and refer to positions so far apart, that it is not possible to fix the centre of the depression with any exactness. It would appear to have been in about Lat. $10\frac{1}{2}^{\circ}$ N. and Long. 91° E. at noon of the 4th.

5TH NOVEMBER (vide *chart of day, Plate XVIII*).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29'835	—'085	—'109	85'0	83	SW	5	102	0'65
Port Blair . . .	29'759	—'051	—'181	78'7	94	SE	18	242	2'35
Diamond Island . . .	29'948	—'024	—'015	75'4	93	NE	14	165	3'48
Rangoon . . .	29'970	—'014	—'008	73'7	95	NNE	7	163	0'41
Akyab . . .	29'959	—'043	—'010	83'1	75	NE	2	91	...
Chittagong . . .	29'953	—'055	—'030	80'7	77	NNE	1	31	...
Calcutta . . .	29'989	—'054	—'005	77'5	61	NNE	3	103	...
Saugor Island . . .	29'987	—'057	—'031	79'4	61	NNE	7	111	...
False Point . . .	29'975	—'061	—'041	79'8	64	NNE	10	164	...
Gopalpur . . .	29'985	—'042	+ '008	81'5	56	NNW	7	92	...
Vizagapatam . . .	29'959	—'047	+ '021	81'5	49	N	2	77	...
Cocanada . . .	29'945	—'045	?	79'0	68	N	12	?	...
Masulipatam . . .	29'926	—'048	+ '042	81'6	65	N	5	85	...
Madras . . .	29'922	—'063	—'049	85'5	68	NNE	9	130	0'77
Negapatam . . .	29'953	—'010	—'003	74'8	98	NW	5	96	6'28
Trincomalee . . .	29'886	—'056	—'041	82'5	83	Calm	8	119	0'02
Galle . . .	29'908	—'039	—'030	79'5	91	W	4	111	...
Nagpur . . .	30'024	—'047	+ '013	77'2	41	NNE	5	185	...
Bombay . . .	29'990	—'010	+ '005	84'0	57	NE	11	111	...
Patna . . .	30'044	—'048	+ '004	79'0	60	Calm	0	0	...
Allahabad . . .	30'050	—'048	+ '033	79'2	41	SE	1	83	...
Lahore . . .	30'027	—'013	+ '018	77'2	37	S	1	71	...

A general fall of the barometer occurred over the whole Indian area during the previous 24 hours. These general cold weather barometric movements common to the whole of India are usually least in the south of the Bay and greatest in Upper India. The local diminution of pressure during the preceding 24 hours was however greatest at Nancowry and Port Blair, and it is hence clear that the fall was mainly due to the development of the local depression. The observations, when charted, indicate that a depression of moderate intensity was now established over a portion of the Bay to the west and south-west of the Andamans, and that its centre was in about Lat. 11° N. and Long. 90° E. The winds were blowing cyclonically over this area, and the evidence is sufficient to prove

that in the eastern and southern quadrants the weather was very squally with heavy rain showers, and was also gradually becoming more stormy.

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Balaarat</i> . . .	At Colombo		?	?	NW	2	Fine weather.
<i>Craigton</i> . . .	7° 33'	82° 42'	30° 32	29° 92	NW	4	4 A.M., light showers; noon, cloudy; midnight, dark, gloomy weather.
<i>Akbar</i> . . .	10° 19'	92° 31'	?	?	SW	?	Early morning, strong wind, high sea with blinding rain-squalls; 1 P.M., fresh gale with heavy sea, and much rain.
<i>Clan Buchanan</i> . .	19° 49'	86° 34'	29° 79	29° 95	NE	3	Fine and clear.

The *Akbar* passed out of the Andaman Sea into the Bay of Bengal early in the morning, and advanced into the storm which had been forming during the previous three days. She had strong winds with blinding rain during the morning, and a fresh gale with a heavy sea in the afternoon. Her log hence indicates the strength of the south-west winds feeding into the cyclone. She was at least 150 miles to the west-south-west of the centre, and quite in the outer gale circle. The *Balaarat* had fine weather at Colombo, and the *Craigton* passing along the east coast of Ceylon, light winds with cloudy gloomy weather. The weather was fine and clear at the head of the Bay with moderate north-east winds.

6TH NOVEMBER (*vide chart of day, Plate XVIII.*)

10 A.M. observations (*chiefly at coast stations*).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 31° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29° 885	+° 050	-° 059	78° 0	90	SSE	3	54	0° 85
Port Blair . . .	29° 825	+° 066	-° 115	77° 3	93	SSE	14	189	1° 73
Diamond Island . . .	29° 910	-° 038	-° 054	75° 9	91	NE	17	200	1° 48
Rangoon . . .	29° 960	-° 010	-° 019	76° 1	52	NE	7	163	0° 04
Akyab . . .	29° 944	-° 015	-° 028	79° 5	82	NNE	2	91	...
Chittagong . . .	29° 941	-° 012	-° 059	80° 7	73	NE	1	31	...
Calcutta . . .	29° 976	-° 013	-° 036	80° 0	58	NNE	3	103	...
Saugor Island . . .	29° 998	+° 011	-° 028	80° 4	58	NE	7	111	...
False Point . . .	29° 947	-° 028	-° 073	81° 3	65	NE	11	180	...
Gopalpur . . .	29° 942	-° 043	-° 039	80° 5	58	Calm	3	39	...
Vizagapatam . . .	29° 907	-° 052	-° 077	81° 5	52	NW	1	38	...
Cocanada . . .	29° 906	-° 039	?	77° 5	63	N	9	?	...
Masulipatam . . .	29° 895	-° 031	-° 076	82° 1	54	N	3	51	...

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	Wind			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Madras	29.894	—0.208	—0.079	80.5	74	NNW	7	101	0.25
Negapatam	29.878	—0.075	—0.089	80.9	81	NNW	7	135	1.60
Trincomalee	29.851	—0.035	—0.077	79.0	95	W	8	119	1.20
Galle	29.915	+0.007	—0.023	77.0	93	Calm	7	194	2.31
Nagpur	29.993	—0.031	—0.022	77.2	42	NNE	6	222	...
Bombay	29.990	0	+0.003	80.5	59	ENE	12	121	...
Patna	30.024	—0.020	—0.020	79.0	60	E	1	67	...
Allahabad	30.028	—0.022	+0.005	78.7	56	N	1	83	...
Lahore	30.018	—0.009	+0.004	76.7	44	E	2	143	...

An unequal fall of the barometer took place during the previous 24 hours over the Indian area, and pressure was very uniform over the northern half of the country. The barometer rose locally at Port Blair and Nancowry, due evidently to the westward movement of the depression, the centre of which was now nearly midway between the Andamans and the Coromandel coast, and in Lat. $11\frac{1}{2}^{\circ}$ N. and Long. $88\frac{1}{2}^{\circ}$ E. at 10 A.M. Winds were strong at Port Blair and Diamond Island and also on the south and east coasts of Ceylon, which received heavy rain during the day. Elsewhere winds were very light, unsteady, and variable in direction. A few heavy showers fell in Southern India, but rain practically ceased in that area on the 5th, and until the approach of the cyclonic storm to the Madras coast, which brought up clouds and rain from the Bay. 1.73 inches were recorded at Port Blair and 3.32 inches at Cocos Island at 10 A.M. of the 7th. One or two showers of no importance fell in South Burma.

Noon observations taken on board ships in the Bay of Bengal and Arabian Sea.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Ballaarat</i>	6° 46'	82° 14'	29.98	29.85	Var.	1 to 4	Morning, heavy rain and vivid lightning; noon, cloudy; midnight, squally with rising sea.
<i>City of Cambridge</i>	6° 55'	77° 26'	29.86	29.90	Var.	1 to 2	Light airs, cloudy, showery.
<i>Akbar</i>	9° 24'	89° 58'	29.69	29.81	SW	?	Morning, strong wind and heavy rain-squalls; noon, clear sky, strong winds; 4 P.M., strong gale and head sea; 8 P.M., heavy rain.
<i>Craigton</i>	10° 17'	83° 27'	30.25	29.85	NNW	6	Morning, squally with rain and lightning; 4 P.M., heavy rain; midnight, heavy confused sea.
<i>Tibre</i>	River Hooghly		29.96	29.96	Calm	0 to 1	Fine weather throughout.

The ship observations for the 6th are too few in number to enable the position of the centre of the disturbance to be fixed with exactness. It was probably in Lat. $11\frac{1}{2}^{\circ}$ N. and Long. 88° E. at noon. The *Craigton*, 300 miles to the west-south-west, had squally weather with heavy rain, and strongish north-north-west winds, force 6. The *Ballaarat*, rounding the south-east and east coasts of Ceylon, had very variable winds. The weather was unsettled and squally, with occasional heavy rain, and a rising sea. The *Akbar* was to the south-east of the centre at a distance of about 200 miles, and crossing the Bay in a west-south-west direction with a velocity approximately equal to that of the centre. She encountered throughout the day very strong winds, heavy squalls, and a high sea. She was in the outer gale circle, and yet the current which she experienced during the previous 24 hours had carried her (if her log may be trusted) 160 miles to the N. 70° E., or at a rate of between 6 and 7 miles per hour. This gives some indication of the steadiness and strength of the south-west winds blowing into the cyclonic whirl.

7TH NOVEMBER (vide chart of day, Plate XVIII).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29'928	+043	-016	83'2	83	SW	6	120	1'59
Port Blair . . .	29'819	-006	-122	79'7	91	SE	19	253	3'20
Diamond Island . . .	29'938	+028	-027	78'4	84	ENE	16	188	0'10
Rangoon . . .	29'987	+027	+007	79'6	81	ENE	7	163	...
Akyab . . .	29'967	+023	-008	81'1	66	NE	2	91	...
Chittagong . . .	29'982	+041	-022	78'2	83	NE	1	31	...
Calcutta . . .	30'001	+025	-021	78'5	61	NE	4	138	...
Saugor Island . . .	29'999	+001	-031	79'4	66	NE	7	111	...
False Point . . .	29'950	+003	-071	82'8	58	NE	12	197	...
Gopalpur . . .	29'937	-005	-048	84'6	53	NE	6	79	...
Vizagapatam . . .	29'888	-019	-100	79'0	60	NNE	3	115	...
Cocanada . . .	29'862	-044	?	81'5	65	NE	11	?	...
Masulipatam . . .	29'853	-042	-121	83'6	64	N	4	68	...
Madras . . .	29'858	-036	-117	73'0	81	N	9	130	0'06
Negapatam . . .	29'861	-017	-097	77'8	81	NW	5	96	...
Trincomalee . . .	29'846	-005	-083	76'5	95	W	9	134	1'03
Galle . . .	29'863	-052	-075	80'5	91	NW	9	250	1'40
Nagpur . . .	29'997	+004	-022	77'7	46	NE	6	222	...
Bombay . . .	29'986	-004	-003	79'5	60	ENE	13	131	...
Patna . . .	30'053	+029	+010	78'5	70	ENE	1	67	...
Allahabad . . .	30'054	+026	+021	80'2	50	ENE	1	83	...
Lahore . . .	30'021	+003	+002	79'2	40	Calm	1	71	...

A slight increase of pressure had taken place during the preceding 24 hours in the whole of India beyond the area of cyclonic disturbance, which now began to include the west coast districts of the Bay. The observations indicate that the centre of the depression was, at 10 A.M., in about Lat. 12° N. and Long. $86\frac{1}{4}^{\circ}$ E. The very small barometric changes at False Point, Saugor Island and Port Blair show that the general disturbance was now covering a larger area than hitherto, whilst the logs of the ships prove that it was increasing in intensity. Winds were much stronger at Port Blair and Nancowry and on the Ceylon coast. The extending indraught to the whirl during the preceding 24 hours was shewn more especially by the increasing force of the winds on the coasts of Ganjam and the Circars, which were now blowing twice as strongly as on the 6th. Over the greater part of Northern India the winds were very light. The average air motion over the whole of the interior of the country in Northern India beyond the direct influence of the cyclonic vortex, was less than 30 miles during the previous 24 hours, or barely 1 mile per hour. Heavy rain fell in Ceylon and the Bay Islands. Over the whole of the land area of India and Burma the day was practically rainless. Port Blair registered 3·2 inches, Cocos Island 1·1 inches, Nancowry 1·59 inches and Galle 1·5 inches.

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>City of Cambridge</i>	$6^{\circ} 15'$	$81^{\circ} 38'$	29·78	29·82	Var.	1 to 2	Light airs and cloudy weather.
<i>Akbar</i> . . .	$8^{\circ} 40'$	$87^{\circ} 56'$	29·70	29·80	SW	?	Morning, continued heavy gale with blinding rain-squalls; noon, strong gale; 8 P.M., wind and sea increasing; midnight, heavy gale and high sea.
<i>Ballaarat</i> . . .	$10^{\circ} 44'$	$81^{\circ} 42'$	29·93	29·80	W	6	Morning, overcast sky, confused swell; noon, squally; afternoon, heavy rain; midnight, hard squalls.
<i>Craigton</i> . . .	$11^{\circ} 47'$	$83^{\circ} 40'$	30·08	29·68	NW N	6	Morning, violent squalls and heavy rain; afternoon, heavy confused sea.
<i>Tibre</i> . . .	$19^{\circ} 1'$	$86^{\circ} 15'$	29·94	29·92	NE	4	Wind increased steadily in force during day from 1 to 8.

The centre of the cyclonic whirl was in Lat. 12° N. and Long. 86° E. at noon of this day, and had advanced 140 miles during the previous 24 hours. The *Craigton* at that hour was about 150 miles to the west, and in the outer circle during the whole day. Violent squalls passed over the vessel at intervals, and heavy rain fell during the day. The *Ballaarat*, further to the west, and approaching Madras, experienced similar winds and weather, and in the evening, with the wind at north-west (force 7) she had heavy rain with hard squalls. The *Akbar* was steaming slowly to the west-south-west against the strong south-west winds in the south-east quadrant, and was at about the same distance and in the same direction from the centre as on the 6th. The weather was evidently worse, as she experienced blinding rain-squalls early in the morning, and the wind and sea increased during the afternoon. The current was not quite so strong, but was estimated at 131 miles during the previous 24 hours.

8TH NOVEMBER (vide chart of day, Plate XVIII).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	Wind			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29'980	+ '052	+ '036	83'6	81	SE	3	66	0'13
Port Blair . . .	29'932	+ '113	— '009	76'7	93	SSE	11	153	1'57
Diamond Island . . .	29'935	— '003	— '031	77'4	93	ESE	27	318	3'38
Rangoon . . .	30'009	+ '022	+ '028	75'7	91	ESE	7	163	0'08
Akyab . . .	30'024	+ '057	+ '046	71'9	95	ENE	4	182	0'95
Chittagong . . .	29'991	+ '009	— '006	75'6	85	SE	1	31	...
Calcutta . . .	29'982	— '019	— '028	77'5	71	E	4	138	...
Saugor Island . . .	29'949	— '050	— '075	78'4	82	ENE	7	111	...
False Point . . .	29'924	— '026	— '094	82'3	75	ENE	16	262	0'19
Gopalpur . . .	29'906	— '031	— '083	80'5	70	NE	10	132	...
Vizagapatam . . .	29'815	— '073	— '177	83'0	57	NE	3	115	0'30
Cocanada . . .	29'788	— '074	P	80'5	74	NE	20	?	...
Masulipatam . . .	29'765	— '088	— '212	82'6	63	N	6	102	...
Madras . . .	29'757	— '201	— '220	79'0	78	NNW	9	130	0'63
Negapatam . . .	29'826	— '035	— '133	77'3	81	W	4	77	0'11
Trincomalee . . .	29'812	— '034	— '118	82'0	71	SW	8	119	0'02
Galle . . .	29'866	+ '003	— '072	81'5	91	W	12	333	0'13
Nagpur . . .	29'968	— '029	— '055	79'7	47	NE	8	296	...
Bombay . . .	29'960	— '026	— '031	79'0	57	ENE	13	131	...
Patna . . .	30'049	— '004	+ '012	80'1	58	ENE	2	133	...
Allahabad . . .	30'048	— '006	+ '011	78'2	58	E	2	167	...
Lahore . . .	30'061	+ '040	+ '037	75'1	48	E	1	71	...

The barometric changes of the previous 24 hours were mainly dependent on the movement of the depression. The barometer had fallen considerably over the west coast of the Bay, and more especially at Madras, and was rising over the east of the Bay. Pressure was, as it had been for some days, remarkably uniform over the whole of Northern India. The centre of the depression at 10 A.M. was in about Lat. $12\frac{1}{2}^{\circ}$ N. and Long. $84\frac{1}{2}^{\circ}$ E., and steep gradients were now established over the Coromandel coast districts. Winds were strong over the whole of the Bay. They were light and unsteady in Upper India, but had already begun to shift round in Central and Southern India, so that the general cyclonic circulation of which the storm was the central and most prominent feature now extended over the Bay, and nearly the whole of Southern and Central India. Over the greater part of this area, the velocity of the wind did not exceed 5 to 10 miles per hour, but over a large part of the south-west of the Bay winds of force 8 or upwards (Beaufort Scale) were now blowing.

Rain ceased to fall in Ceylon but continued in the Bay Islands and extended to South Burma. It was also commencing in the Madras coast districts, but the amounts registered were as yet very small. Port Blair received 1.57 inches, and Diamond Island 3.38 inches. The rainfall in the land area during the preceding 24 hours was largest and most general in Pegu, which received an average of nearly 1½ inches.

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Investigator</i>	6° 27'	83° 34'	29.70	29.82	SW	...	6 A.M., south-westerly sea; 2 P.M., northerly swell; 4-20 P.M., SW and WNW swell.
<i>Akbar</i>	7° 39'	86° 31'	29.70	29.80	SW	?	1 A.M., wind slightly moderating, and very high cross sea, shipping water fore and aft; 4 A.M., same weather; 8 A.M., less wind and sea, sky clear; 11 A.M., shipped a very heavy sea over the bows, which flooded the decks fore and aft; violent squall of wind and blinding rain, wind flying into the WNW; noon, moderate gale, shipping large quantities of water; 1 P.M., wind and sea moderating; 3 P.M., moderate and clear weather, fresh breeze; midnight, fresh breeze and head sea.
<i>City of Cambridge</i>	9° 43'	83° 28'	29.68	29.72	WSW	6	4 A.M., fresh winds, heavy NW sea, overcast; 8 A.M., strong winds, confused sea, overcast; noon, strong breeze with heavy westerly sea; 4 P.M., strong wind squalls, dark and threatening to the NNW, high cross sea; 5 P.M., barometer falling, steered to the eastward; 8 P.M., barometer rising, wind SSW, heavy squalls, heavy cross sea, kept course again; midnight, strong winds, heavy squalls and sea.
<i>Ballaarat</i>	12° 46'	80° 43'	29.85	29.72	WNW	5	Morning, overcast with frequent heavy squalls of wind and rain, confused sea from NNW and NE; 5-30 P.M., stood to SSE.
<i>Craigton</i>	13° 0' (D. R.)	84° 00' (D. R.)	29.40	29.00	SW	?	4 A.M., cyclone apparently commencing; 8 A.M., heavy sea from all quarters; noon, complete hurricane continuing till midnight.
<i>Tibre</i>	15° 20'	82° 00'	29.69	29.69	NE	8	

The observations shew that the centre had advanced during the 24 hours preceding noon of this day to Lat. 13° N. and Long. 84° E., or over a distance of about 150 miles in a west-north-westerly direction. They also indicate that the storm had grown considerably in intensity during the previous 24 hours, and was now a cyclonic whirl, with a small inner area of large barometric depression and hurricane winds, and an outer area of

considerably larger diameter (400 to 600 miles) of violent squalls, strong winds, and a heavy sea. The *Craigton* was involved in the storm early in the morning. According to the brief account of the Captain, he began to encounter the storm at 4 A.M. At 8 A.M. he had a heavy sea from all directions, an indication apparently that he was near or in the centre. The ship was evidently carried along with the storm, for she had a complete hurricane from noon until early next morning. The position of the vessel at noon as estimated by dead reckoning is given as Lat. 13° N. and Long. 84° E. The lowest reading of the barometer was taken during the afternoon and was $28\cdot4$ "corrected."

The *Ballaarat* was 230 miles to the west of the centre at noon. She had frequent heavy squalls of wind and rain with a very confused sea. As the centre advanced westwards, thus diminishing its distance from the *Ballaarat*, the weather became so threatening that the Captain turned the ship's head to S.S.E. and ran southward.

The *City of Cambridge* was 250 miles to the south of the centre at noon. She had fresh W.S.W. winds in the morning; as she advanced northwards the winds became stronger and frequent heavy squalls came down and passed over the vessel. The Captain changed her course to east for some hours and the weather improved.

The *Investigator*, 200 miles further south, had ordinary N.W. winds, force 4, with a moderate swell.

The *Akbar* was 400 miles to the S. S. W. and advancing, as hitherto, against the strong south-west winds feeding into the cyclone. She had however considerably increased her distance from the centre during the past 24 hours. She experienced very strong winds and a high and almost dangerous sea during the morning. At 11 A.M. a very heavy sea struck the vessel and flooded the decks fore and aft. This was followed by a very violent squall from the W. N. W. with blinding rain. After noon the weather began to improve, and at 8 P.M. it was clear and fine with a moderate S. W. breeze.

9TH NOVEMBER (vide chart of day, Plate XIX).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A. M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A. M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A. M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of wind to average amount expressed as a percentage.	
Nancowry . . .	30.036	+0.056	+0.092	84.0	79	ESE	6	126	0.23
Port Blair . . .	29.911	—0.021	—0.031	83.5	87	SE	14	185	0.50
Diamond Island . . .	29.976	+0.041	+0.009	80.4	87	E	19	224	0.17
Rangoon . . .	30.019	+0.010	+0.037	79.6	86	ENE	5	116	0.15
Akyab . . .	30.030	+0.006	+0.049	68.9	95	E	6	273	1.33
Chittagong . . .	29.985	—0.006	—0.024	77.7	83	ESE	1	31	...
Calcutta . . .	29.978	—0.004	—0.038	78.5	74	E	3	103	...
Saugor Island . . .	29.955	+0.006	—0.082	78.4	82	ENE	6	95	...
False Point . . .	29.936	+0.012	—0.095	80.8	82	NNE	13	213	0.17
Gopalpur . . .	29.923	+0.017	—0.070	79.5	78	NNE	13	171	0.12
Vizagapatam . . .	29.850	+0.035	—0.146	77.0	82	NE	4	154	0.80

STATIONS.	Barometer 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Tempera- ture at 10 A.M.	Humidity at 10 A.M.	Wind.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to aver- age amount expressed as a percentage.	
Cocanada	29.788	0	?	77.5	84	NE	34	?	0.05
Masulipatam	29.719	-.046	-.261	75.7	91	NE	12	203	0.04
Madras	29.463	-.294	-.516	71.5	93	W	17	246	1.87
Cuddapah	29.841	-.060	-.170	71.8	90	?	?	?	0.06
Kurnool	29.789	-.083	-.208	82.0	73	?	?	?	...
Bellary	29.825	-.086	-.139	77.4	68	N	8	242	...
Belgaum	29.851	-.132	-.113	74.8	61	NNE	15	128	...
Negapatam	29.742	-.081	-.218	77.8	83	SW	5	96	...
Trincomalee	29.784	-.028	-.147	79.5	76	SW	9	134	...
Galle	29.860	-.006	-.078	81.0	85	NW	16	444	0.24
Nagpur	29.950	-.018	-.077	79.2	46	NE	8	296	...
Bombay	29.925	-.035	-.069	81.0	59	NE	13	131	...
Patna	30.037	-.012	-.011	78.5	61	ENE	1	67	...
Allahabad	30.050	+0.002	+0.007	78.7	58	NE	1	83	...
Lahore	30.012	-.049	-.017	76.2	49	E	2	143	...

The meteorological observations of the 9th shew that the changes of pressure during the previous 24 hours beyond the storm area were comparatively small. Pressure was very uniform over the greater part of Northern India. The winds in Upper India were apparently in no way related to the storm. Over the whole of the Bay and Central and Southern India, the lower atmospheric circulation was cyclonic in character. Winds were still blowing strongly at the Bay Islands and in South Burma, whilst they had increased very greatly in strength on the west coast and at the Ceylon stations. The observations indicate that the centre of the depression and cyclonic circulation was near the Madras coast at 10 A.M., probably about 40 miles to the north-east of Madras. It had hence travelled about 220 miles during the preceding 24 hours, or at the rate of 9 miles per hour. It crossed the coast about 50 miles to the north of Madras between 1 and 2 P.M. The barometer was lowest at Madras at 1 P.M., when the corrected reading was 29.272", and the wind velocity was 45 miles per hour. The rainfall at Madras was moderate in amount, and no lightning was observed during the cyclone at that station. The centre passed over Cuddapah in the evening, probably about 6 P.M. Rain fell over the greater part of Southern India on the 9th, and also in Burma. The amounts recorded in Southern India were much smaller than might have been expected from the intensity of the storm, and only exceeded 5 inches in three cases, given in the following table:—

Districts.	Stations.	Rainfall, Inches.
Nellore	Tada	5.35
North Arcot	Chandragiri	5.10
Tumkur	Tumkur	5.70

No rain fell in Madura and Trichinopoly or on the western coast of India before the afternoon of the 9th.

Observations taken on board ships in the Bay of Bengal and Arabian Sea.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Akbar</i>	Noon	7° 1'	83° 42'	29'80	29'92	SW	...	Morning, fresh wind and cross sea; noon, strong breeze and head sea.
<i>Ballaarat</i>	4 A.M.	...	...	29'88	29'75	SW	5	Overcast, squally, high confused sea.
	Noon	10° 50'	80° 58'	29'87	29'74	SW	7	5-35 P.M., weather threatening; stood to south.
	8 P.M.	...	...	29'87	29'74	SSW	8	11-30 P.M., weather improved; stood again north.
<i>City of Cambridge</i>	4 A.M.	...	...	...	...	S by E	4 to 6	Weather clear.
	8 A.M.	...	...	...	...	...	...	Fresh winds; heavy bank of clouds from WNW to WSW.
	Noon	13° 21'	85° 18'	29'78	29'82	SE by E	4	Moderate winds and high confused sea.
	Mid-night.	...	...	...	...	...	...	Gentle winds and fine weather; sea going down.
<i>Craigton</i>	4 A.M.	...	...	29'50	29'10	SSE	...	Violent squalls with high dangerous sea.
	Noon	14° 20' (D.R.)	84° 10' ? (D.R.)	29'90	29'50 ?	SSE	...	Squally; much rain.
	Mid-night.	...	...	30'10	29'70 ?	...	...	Passing clouds; light SE swell.
<i>Golden Horn</i>	Noon	10° 1'	74° 00'	29'85	29'83	NW	...	Moderate winds; fine clear weather.
<i>Sierra Pedrosa</i>	Noon	10° 57'	74° 31'	30'08	29'85	NW	...	Brisk breeze and cloudy.
	8 P.M.	...	...	30'04	29'81	NW by W	...	Light breeze, with very wet, greasy sky.
	Mid-night.	...	...	...	...	WNW	...	Light to moderate breeze, very unsteady in force and direction; passing showers and overcast sky.
<i>Gelert</i>	8 A.M.	...	...	...	...	NW	...	Fresh wind and fine clear weather.
	Noon	11° 1'	74° 42'	30'30	29'86	NW	...	Fresh wind and fine clear weather.
	8 P.M.	...	...	...	...	NW	...	Fresh wind and overcast sky; showery.
<i>Trossachs</i>	Noon	11° 4'	73° 33'	30'08	29'86	NW	...	Clear weather.
	Mid-night.	...	...	...	...	NW by W	...	Heavy banks of clouds on the horizon; threatening rain.
<i>Madura</i>	4 A.M.	...	...	29'78	29'87	N by W	...	Fine and clear.
	Noon	15° 27'	73° 32'	29'77	29'86	NW by W	...	Moderate breeze and fine clear weather.
	4 P.M.	...	...	29'75	29'84	NNW	...	Clear weather.
	Mid-night.	...	...	...	...	NNW	...	Moderate breeze and fine weather; sky overcast.

The vessels in the Bay which contributed logs were now all in the eastern or southern quadrant. Their logs shew that the inner storm area (of hurricane winds and of large baric gradients) was of comparatively small dimensions. The *City of Cambridge* was 300 miles east of the centre at noon. She had fresh winds in the morning, but as she advanced northwards they decreased in strength, and she experienced gentle winds with fine weather in the evening. The *Craigton* was probably in Long. 82° E. and not in Long. 84° 10' E.

as calculated by dead reckoning. Violent squalls passed over the vessel during the morning. The weather improved rapidly after noon, and winds fell light towards evening.

The *Ballaarat* and *Akbar*, both in the southern quadrant, had throughout the day strong winds and a heavy swell. Both were in the outer storm area, and the *Ballaarat* judiciously steamed slowly south during the greater part of the day. Both vessels experienced a considerable improvement in the weather during the afternoon and evening.

There were several vessels on the west coast of India steaming northwards to Bombay. North-westerly winds of moderate strength prevailed throughout the day, and the weather was fine and clear until the afternoon, when skies began to cloud over, and before midnight skies were overcast, and rain began to fall in light showers near the coast in Lat. 11° N.

10TH NOVEMBER (vide chart of day, Plate XIX).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A. M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	30'007	—'029	+ '063	84'6	79	E	3	56	0'22
Port Blair . . .	29'962	+ '051	+ '020	82'7	87	SW	4	53	...
Diamond Island . . .	30'017	+ '041	+ '049	73'9	94	NNE	13	153	2'09
Rangoon . . .	30'022	+ '003	+ '039	78'6	86	NNE	5	116	...
Akyab . . .	30'027	—'003	+ '043	77'0	88	SE	7	318	0'43
Chittagong . . .	30'000	+ '015	—'016	78'2	85	ESE	2	63	...
Calcutta . . .	30'005	+ '027	—'025	78'5	78	NE	3	103	...
Saugor Island . . .	29'989	+ '034	—'054	79'4	78	NE	5	79	...
False Point . . .	29'991	+ '055	—'044	80'8	67	NE	12	197	0'81
Gopalpur . . .	29'982	+ '059	—'015	78'5	86	NE	7	92	0'92
Vizagapatam . . .	29'947	+ '097	—'053	80'0	85	W	2	77	3'80
Cocanada . . .	29'932	+ '144	?	81'5	83	ESE	20	?	1'63
Masulipatam . . .	29'896	+ '177	—'087	80'6	85	SE	13	220	1'41
Madras . . .	29'820	+ '404	—'114	83'5	73	SSW	19	275	1'71
Negapatam . . .	29'845	+ '103	—'116	83'9	78	SW	5	96	...
Trincomalee . . .	29'873	+ '089	—'059	84'5	54	SW	7	104	...
Galle . . .	29'913	+ '053	—'025	80'0	89	Calm	7	194	...
Nagpur . . .	29'956	+ '006	—'075	79'7	54	NE	10	370	...
Bombay . . .	29'859	—'066	—'137	81'5	52	NE	12	121	...
Patna . . .	30'046	+ '009	—'010	80'1	60	ESE	1	67	...
Allahabad . . .	30'047	—'003	—'004	78'7	51	SE	1	83	...
Lahore . . .	30'020	+ '008	—'014	77'2	46	Calm	1	71	...
Bellary . . .	29'745	—'080	—'221	73'0	86	N	13	394	0'93
Belgaum . . .	29'760?	—'091?	—'206?	66'4	95	NNE	20	171	...
Cuddapah . . .	29'842	+ '001	?	80'3	70	?	?	?	1'50
Bangalore . . .	29'861	+ '016	—'155	67'7	90	SE	14	378	5'54
Ratnagiri . . .	29'799	—'087	—'152	87'0	44	NE	10	111	...
Goa . . .	29'814	+ '005	?	75'0	86	E	3	?	0'18

The barometric changes in Northern India during the previous 24 hours were very small. A large redistribution of pressure had occurred over the Bay and in Southern India, due to the transference of the depression and cyclonic disturbance across North Mysore. A very rapid rise had taken place in the Bay and the Coromandel coast districts, and a moderate fall at Bellary, Belgaum, and Ratnagiri. The centre was nearly midway between Bellary and Belgaum at 10 A.M. The barometric height at the centre was almost certainly not less than 29.7". Hence the depression had filled up to a very considerable extent during its passage across the Peninsula, and the air circulation was now comparatively feeble. This is further confirmed by the moderate increase in the strength of the wind at the Mysore and South Deccan stations on the approach of the cyclone, and by the diminished rainfall over the area of disturbance. The rainfall of the 10th, was chiefly confined to the northern districts of Madras, Hyderabad, Mysore and the midwest Bombay coast, and the amounts registered were much smaller than on the 9th. Hence it is almost certain that the storm was nearly exhausted, and that its passage across the Peninsula (through a distance of 450 miles) had deprived it of the greater part of its energy. The supply of energy during this interval was in fact not equal to that necessary to overcome the various resistances to its motion, and to maintain its motion undiminished. The only apparent cause was the slight rainfall over the area of depression as it moved across the peninsula. The storm passed out to sea after having crossed the Western Ghâts in the neighbourhood of Belgaum and the coast in the neighbourhood of Goa in about Lat. $15\frac{1}{2}^{\circ}$ N. late on the afternoon of the 10th. There are no observations which throw any light on the nature of the changes which occurred during its transfer across the Ghâts and its descent to the sea.

Noon observations taken, on board ships in the Bay of Bengal.

NAMES OF SHIPS.	HOUR.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>City of Cambridge.</i>	Noon	17° 44'	86° 54'	29.92	29.98	ESE to N	3 to 1	Light winds, fine clear weather.
<i>Craigton</i>	Noon	16° 10'	83° 28'	30.15	29.90 ?	SE	4	Fine weather and passing clouds.
	Mid-night.	...	...	...	...	Var.	1	
<i>Ballaarat</i>	Noon	12° 16'	81° 3'	29.98	29.85	S to ENE	5 to 4	Fine cloudy weather.
<i>Investigator</i>	8 A.M.	9° 0'	88° 28'	29.83	29.85	SSE	4	Southerly swell.
<i>Akbar</i>	Noon	6° 2'	81° 7'	29.75	29.87	W	...	Very light winds; heavy rain squalls.
	Mid-night.	...	...	...	...	...	...	Light breeze and clear sky.

The observations taken on board ships on this day in the Bay shew that fine weather with light winds was again established over the west and south of the Bay. Similar weather prevailed in the Bay Islands and at Diamond Island, and it is hence almost certain that ordinary north-east monsoon weather with clear skies extended over the whole of the Bay before the evening of the 10th.

Observations taken on board ships in the Arabian Sea.

NAMES OF SHIPS.	HOUR.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Golden Horn</i>	6 A.M.	...	...	...	...	WNW	...	Morning, squally and heavy rain.
	Noon	12° 6'	74° 50'	29.70	29.83	SW	...	Light winds and squally; heavy rain.
	6 P.M.	...	...	...	...	SSW	...	Very threatening weather.
<i>Sierra Pedrosa</i>	1 A.M.	...	...	...	...	W	...	Thick dirty weather with continuous rain.
	8 A.M.	...	...	30.00	29.82	NW	...	
	Noon	12° 34'	74° 34'	29.98	29.80	NW	...	Thick overcast weather and heavy rain.
	6 P.M.	...	...	...	...	WSW	...	Moderate gale and dirty thick weather, with continuous heavy rain and moderate sea.
	Mid-night.	...	...	...	...	SW	...	
<i>Trossachs</i>	8 A.M.	...	...	...	...	NW	...	Squally, with heavy rain.
	Noon	12° 36'	74° 12'	30.07	29.83	Var.	...	Rain; dark threatening weather; heavy swell.
	8 P.M.	...	...	...	...	W	...	Breeze increasing fast; heavy rain and squally.
	Mid-night.	...	...	...	...	W	...	Very heavy squalls and steady hard rain.
<i>Gelert</i>	1 A.M.	...	...	...	...	NW	...	Moderate breeze and showery.
	8 A.M.	...	...	...	...	...	...	Heavy rain with sharp squalls.
	Noon	13° 52'	74° 12'	30.20	29.76	NW	...	Fresh wind with dull gloomy weather and drizzling rain.
	8 P.M.	...	...	...	...	NW	...	Light wind and drizzling rain.
	Mid-night.	...	...	...	...	SW	...	Blowing hard; very heavy squalls with rain.
<i>Waverley</i>	4 A.M.	...	...	...	...	NE by E	...	Moderate breeze; clear weather.
	Noon	16° 51'	63° 39'	29.92	29.90	NE by E	...	Fine clear weather; moderate breeze.
	2 P.M.	...	...	...	...	NE	...	Ditto ditto.
	Mid-night.	...	...	...	...	NE	...	Ditto ditto.
<i>Atrato</i>	1 A.M.	...	...	30.30	29.90	NE by N	2	Fine clear weather; smooth sea.
	Noon	17° 21'	63° 54'	...	...	NE	4	Ditto ditto.
	6 P.M.	...	...	30.25	29.85	NE	5	Wind freshened, sea rising.
	Mid-night.	...	...	...	...	NE	5	Short sea.
<i>Madura</i>	4 A.M.	...	...	29.77	29.85	N	...	Fresh breeze and fine clear weather.
	Noon	18° 14'	72° 48'	29.77	29.85	NNW	...	Moderate breeze; fine weather; sky overcast.
	4 P.M.	...	...	29.75	29.83	N by W	...	Fresh breeze and fine.
<i>Java</i>	4 A.M.	...	...	...	...	N	...	Moderate winds and fine.
	Noon	21° 5'	69° 13'	30.18	29.95	N	...	Ditto ditto.
	4 P.M.	...	...	30.12	29.89	N	...	Ditto ditto.
	Mid-night.	...	...	30.12	29.89	N	...	Moderate light breeze and fine weather.

Eight vessels give information respecting the weather in the Arabian Sea on this day. The storm centre passed out to sea in about Lat. $15\frac{1}{2}^{\circ}$ N. late on the evening of the 10th. The *Golden Horn*, *Trossacks* and *Sierra Pedrosa* were all near the Malabar Coast in about Lat. 12° or $12\frac{1}{2}^{\circ}$ N. at noon of the 10th and passing northwards. They had thick, dirty weather with heavy rain during the day, and weather became more threatening as the day advanced. The winds were unsteady until the evening. The weather was very squally to the south of Lat. 16° during the afternoon and evening, and all the vessels near the coast and to the south of Lat. 16° N. experienced very heavy rain during the day, and at night the winds shifted round from north-west to west or south-west. The *Gelert*, for example, which was near the coast in Lat. 14° N. at noon, had sharp squalls and heavy rain in the morning, drizzling rain in the evening, and very heavy squalls with rain and strong winds at midnight. In the case of all these vessels, the winds shifted round late in the evening and blew with considerable force for some hours, but they were more or less unsteady and irregular, thus showing that the cyclonic circulation accompanying the storm at this time was by no means regular or strong. Further north, and over the centre of the Arabian Sea between Aden and Bombay, fine clear weather and moderate breezes prevailed.

Hence the changes of wind direction prove conclusively that the whirl passed out to sea on the evening of the 10th, probably about 4 to 5 P.M., and also that heavy rain fell near and to the south of the storm centre on that evening, and that the southerly winds which blew into it after 6 P.M. were occasionally interrupted by heavy squalls. There were hence already conditions in the Arabian Sea present which favoured the prolongation of the existence of the whirl and the renewal of its strength.

11TH NOVEMBER (vide *chart of day*, *Plate XIX*).
10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Tempera- ture at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to aver- age amount expressed as a percentage.	
Nancowry . . .	30°024	+°017	+°080	81°6	88	E	2	30	0°21
Port Blair . . .	29°966	+°004	+°023	83°2	85	NW	3	36	...
Diamond Island . . .	30°035	+°018	+°066	79°4	80	NNE	8	94	...
Rangoon	30°030	+°008	+°046	79°1	83	NNE	5	116	...
Akyab	30°009	—°018	+°022	78°0	91	SE	3	136	0°30
Chittagong	30°033	+°033	+°018	73°1	97	Calm	2	63	0°45
Calcutta	30°033	+°028	—°004	79°0	58	NE	4	138	...
Saugor Island . . .	30°029	+°040	—°013	80°4	66	NE	5	79	...
False Point	30°015	+°024	—°028	88°3	71	ENE	8	131	...
Gopalpur	30°015	+°033	+°014	80°5	87	Calm	5	66	0°05
Vizagapatam	29°987	+°040	—°017	81°5	79	N	1	38	0°10
Cocanada	29°988	+°056	P	81°5	77	ENE	7	P	0°05
Masulipatam	29°971	+°075	—°015	84°6	70	SE	6	102	0°05

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Madras	29.975	+108	-008	83.0	67	SSE	5	72	0.07
Negapatam	29.973	+128	+011	82.4	70	SW	4	77	...
Trincomalee	29.974	+101	+041	84.0	69	SE	6	90	...
Galle	30.008	+095	+070	78.0	86	Calm	7	194	0.76
Nagpur	30.004	+048	-031	81.2	66	ESE	8	296	...
Bombay	29.905	+046	-093	81.0	74	ENE	15	152	0.03
Ratnagiri	29.890	+091	-062	75.8	86	ESE	16	178	0.13
Karwar	29.906	+062	-048	75.6	87	SW	?	?	0.73
Patna	30.050	+004	-011	79.0	68	Calm	1	67	...
Allahabad	30.033	-014	-030	81.3	51	SSE	1	83	...
Lahore	30.000	-020	-039	78.2	43	W	1	71	...

A rapid increase of pressure had taken place during the preceding 24 hours over the whole of Central and Southern India. The barometer had been stationary over the greater part of the Bay and had fallen slightly in Upper India. Pressure was remarkably uniform over India generally, the baric differences over nearly the whole of the country (excluding the west coast) barely reaching '08". Winds fell off very rapidly in Southern India, and over the greater part of the country light breezes or calms now prevailed. The wind directions in Southern and Western India were, at 10 A.M., still governed by the depression which had passed into the Indian Ocean, but generally reverted to their normal directions before the close of the day. Light showers fell in the Bombay coast districts, but with that exception the day was practically rainless over the whole of India.

Observations taken on board ships in the Bay of Bengal and Arabian Sea.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
Craigton	Noon	18° 12'	84° 53'	29.35	29.95	NNE	3	Showery.
Tibre	Noon	9° 2'	81° 21'	29.92	29.92	SW	2	Fine clear weather.
	8 P.M.	...	...	29.96	29.96	Calm	...	
Akbar	Noon	7° 32'	77° 46'	29.87	29.99	Calm	...	Fine clear weather.
Golden Horn	Noon	13° 52'	73° 58'	29.80	29.93	S	...	Moderate and cloudy.
	Mid-night.	...	...	...	...	SE	...	Fine weather.
Sierra Pedrosa	10 A.M.	...	...	...	...	SSW	...	Morning, weather clearing up, wind moderating and hauling to the south.
	Noon	13° 59'	73° 20'	29.89	29.90	S	...	
	8 P.M.	...	...	29.90	29.91	S	...	Moderate breeze and cloudy southerly sea.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Trossachs</i> . . .	4 A.M.	...	...	...	...	WSW	...	Moderating.
	Noon	14° 51'	73° 7'	30° 15	29° 90	SSE	...	Fresh breeze, with cloudy weather and light showers of rain.
	Mid-night.	...	...	...	...	SSE	...	Light breezes; sky fine and clear.
<i>Gelert</i> . . .	1 A.M.	...	...	...	...	SE	...	Blowing hard with heavy squalls of rain.
	10 A.M.	...	...	...	...	...	...	Weather clearing up and wind moderating.
	Noon	16° 43'	73° 2'	?	?	SE	...	Dark gloomy weather; fresh winds.
<i>Waverley</i> . . .	6 P.M.	...	...	...	...	SE	...	Strong breeze and drizzling rain.
	2 A.M.	...	...	...	...	NE	...	Fine clear weather.
	Noon	17° 26'	66° 43'	29° 91	29° 88	NE	...	Moderate winds, clear weather; 4 P. M., moderate winds with passing showers.
<i>Peshwa</i> . . .	6 P.M.	...	...	...	...	NE by E	...	Moderate winds, clear weather.
	Mid-night.	...	...	29° 80	29° 77	NE by E	...	Strong winds with heavy showers.
	4 A.M.	...	...	29° 88	29° 78	E	4	Fine weather; clouded skies.
<i>Rubattina</i> . . .	Noon	17° 38'	72° 48'	29° 95	29° 85	SE	6	Sky overcast, showery; rising sea.
	8 P.M.	...	...	30° 00	29° 90	SE	6	Fresh winds; overcast.
	Mid-night.	...	...	30° 03	29° 93	SE by S	...	Strong breeze and clear.
<i>Atrato</i> . . .	Noon	18° 13'	69° 24'	...	...	ENE	...	Sea smooth.
	1 A.M.	...	...	30° 25	29° 85	NE by N	5	Fine weather.
	Noon	18° 7'	66° 40'	...	...	NE by E	3	10 P. M., sky threatening; heavy squalls, with thick rain.
<i>Java</i> . . .	8 P.M.	...	...	...	...	NE by E	3	Sea rising rapidly.
	Mid-night.	...	...	...	...	...	...	
	4 A.M.	...	...	30° 12	29° 89	N	...	
	Noon	24° 24'	66° 59'	30° 21	29° 98	NNE	...	Light winds and fine.
	4 P.M.	...	...	30° 20	29° 97	NNW	...	
	Mid-night.	...	...	30° 19	29° 96	NNW	...	Light winds and fine.

Fine clear weather with light winds or calms obtained in the Bay.

The information respecting the weather in the Arabian Sea does not enable the position of the centre to be determined with exactness. The probable position at noon was in about latitude 16° north and longitude 69½° east. It was hence travelling somewhat more slowly than when crossing the Peninsula.

The weather moderated on the Bombay and Malabar coasts during the day to the south of latitude 16° north, and fine clear weather was established before the evening. The *Waverley* was about 200 miles to the west-north-west of the centre at noon, and the *Atrato* 210 miles to the north-west. Both vessels were advancing eastwards towards the cyclone, and had fine weather in the morning. The latter had heavy squalls with thick

rain, and the former strong winds during the evening with heavy showers. The *S. S. Rubattino*, if her position be rightly given, was only about 150 miles to the north of the centre at noon and in the north, and therefore in the least disturbed and stormy quadrant. She had fine weather and a smooth sea. These facts show conclusively that the storm was very small and feeble, and probably did not cover an area more than 120 to 150 miles in diameter, beyond which to the north and west, the weather was fine, skies clear, and sea smooth. This is, of course, additional evidence corroborating the inference drawn from the land observations, that the passage of the storm across the Peninsula had almost completely broken it up, and that it was very small and feeble when it passed into the Arabian Sea.

12TH NOVEMBER (vide *chart of day, Plate XIX*).10 A.M. observations (*chiefly at coast stations*).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	Wind.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29.961	—0.03	+0.017	83.2	82	N	3	62	0.74
Port Blair . . .	29.974	+0.008	+0.031	82.7	87	NNW	2	30	...
Diamond Island . . .	30.032	—0.003	+0.062	80.9	85	NNE	4	47	...
Rangoon . . .	30.026	—0.004	+0.041	81.1	84	ENE	2	47	...
Akyab . . .	30.040	+0.031	+0.050	80.1	79	N	2	91	0.21
Chittagong . . .	30.046	+0.013	+0.025	78.7	83	Calm	1	31	0.02
Calcutta . . .	30.060	+0.027	+0.010	79.3	54	ESE	2	69	...
Saugor Island . . .	30.082	+0.053	+0.030	80.4	74	ENE	3	48	...
False Point . . .	30.060	+0.045	+0.017	84.3	64	E	5	82	...
Gopalpur . . .	30.048	+0.033	+0.043	79.5	90	Calm	4	53	0.50
Vizagapatam . . .	30.043	+0.056	+0.035	82.0	71	W	0	0	...
Cocanada . . .	30.049	+0.061	?	80.5	76	NE	3	?	...
Masulipatam . . .	30.037	+0.066	+0.048	82.6	75	NW	3	51	...
Madras . . .	30.054	+0.079	+0.069	85.0	68	S	3	43	...
Negapatam . . .	30.030	+0.057	+0.067	83.9	75	NW	6	115	...
Trincomalee . . .	30.018	+0.044	+0.084	82.5	77	SW	5	75	0.08
Galle . . .	30.038	+0.030	+0.100	79.0	91	N	3	83	...
Nagpur . . .	30.039	+0.035	0	83.2	63	NNW	3	111	...
Bombay . . .	30.053	+0.148	+0.053	76.5	86	ENE	17	172	0.58
Ratnagiri . . .	30.024	+0.134	+0.070	86.5	62	SSE	11	122	0.09
Karwar . . .	30.036	+0.130	+0.081	81.1	70	W	?	?	0.06
Patna . . .	30.075	+0.025	+0.004	79.6	51	S	1	67	...
Allahabad . . .	30.054	+0.021	—0.018	79.2	53	WSW	2	167	...
Lahore . . .	30.064	+0.064	+0.020	75.1	40	NNE	1	71	...

Pressure continued to rise generally, the increase being greatest in the west coast. The barometric differences over the land area were now exceedingly small. For example, the pressures at Allahabad and Madras were identical, and differed by only '001" from the pressure at Bombay, '006" from that at Calcutta, and '01" from that at Lahore. Pressure was hence remarkably uniform over the whole of the land area. A moderate decrease of pressure had, however, occurred at Nancowry, which accompanied the commencement of another period of rainfall in the Bay Islands. The fall apparently extended over the whole of the Andaman Sea.

The weather in the Bay was fine and clear. None of the ships contributing logs were in the neighbourhood of the Nicobars, and hence the weather conditions can only be inferred from the facts that the barometer began to fall and rain recommenced after a cessation for some days and increased in amount. Skies at Nancowry became overcast and weather dark and gloomy. Northerly winds continued during the day. The fall of the barometer in the south-east of the Bay was as yet comparatively small, but was due to the commencement of the disturbance which initiated the second cyclonic storm.

Winds were very light at all stations with one or two exceptions. Northerly winds obtained in Upper India and also in Bengal, but they were in the latter area mere local winds and not the continuation of the dry winds of the cold weather in Upper India. The previous 24 hours were practically rainless over the whole of India.

Observations taken on board ships in the Bay of Bengal and Arabian Sea.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Craigton</i> . . .	Noon	19° 55'	86° 35'	30°40	30°00	NE to E	2 to 1	Fine clear weather.
<i>Ballaarat</i> . . .	Left Madras at 1 P.M.			...	...	...	...	' Ditto.
<i>Tibre</i> . . .	Noon	6° 15'	79° 30'	30°04	30°02	Calm	0 to 1	Very fine.
<i>Peshawar</i> . . .	4 A.M.	...	...	30°13	...	NE	2	Light breeze and fine.
	8 A.M.	...	...	30°18	...	NE	3	Ditto.
	Noon	15° 39'	57° 19'	30°18	30°05	NE	3	
	4 P.M.	...	...	30°11	...	N	3	Light breeze and fine clear weather; increasing head swell.
	8 P.M.	...	...	30°13	...	N	3	Light wind and fine NE swell.
	Mid-night.	...	...	30°15	...	N	4	Moderate wind and fine NE swell.
<i>Kubattino</i> . . .	Noon	17° 19'	64° 25'	...	...	NNE	...	Fresh winds; sea agitated.
<i>Peshwa</i> . . .	1 A.M.	...	...	...	...	SSE	6	Sea rough.
	8 A.M.	...	...	30°10	...	SSE	6	
	Noon	15° 12'	73° 31'	30°08	30°00	S	5	Fresh breeze and clear; sea confused.
	Mid-night.	...	...	30°10	...	S	...	Light breeze and clear; smooth sea.

NAME OF SHIP.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Trossachs</i>	Noon	16° 53'	73° 38'	30°30	30°04	Var.	...	Clear weather with light breeze.
<i>Atrato</i>	1 A.M.	...	...	30°22	...	NE by E	5	High cross sea.
	2 A.M.	...	...	...	...	ENE	6	
	4 A.M.	...	...	30°10	...	...	6	
	5 A.M.	...	...	...	...	...	7	
	6 A.M.	...	...	30°15	29°75	...	6	Heavy rain; sea decreasing.
	8 A.M.	...	...	30°25	29°85	E by N	...	Fair, squally, but wind abating.
	Noon	18° 38'	68° 27'	30°30	29°90	...	5	Squally, with incessant rain.
	5 P.M.	...	...	30°32	29°92	ENE	5	Fair; cloudy.
	8 P.M.	...	...	...	...	E	4	Fine.
	Mid-night.	...	...	...	...	ESE	3	Fine clear weather; smooth sea.
<i>Clan Sinclair</i>	4 A.M.	...	...	29°76	30°09	NE	...	Light breeze; fine and clear.
	8 A.M.	...	...	29°77	30°10	NE	...	Light breeze; NE swell.
	Noon	14° 54'	53° 32'	29°77	30°10	NE	...	
	4 P.M.	...	...	29°76	30°09	NE	...	Light breeze and fine clear weather.
	8 P.M.	...	...	29°77	30°10	NE	...	
	Mid-night.	...	...	29°78	30°11	NE	...	Gentle breeze; fine and clear.
<i>Golden Horn</i>	Noon	15° 31'	73° 25'	29°90	30°03	SE	...	Light winds; fine clear weather.
	Mid-night.	...	...	...	...	SSE	...	Light winds; fine clear weather.
<i>Mecca</i>	4 A.M.	...	...	30°22	30°05	E	...	Light winds, and fine throughout the day.
	8 A.M.	...	...	30°28	30°11	N	...	
	Noon	14° 36'	54° 47'	30°27	30°10	N	...	
	4 P.M.	...	...	30°25	30°08	N	...	
	8 P.M.	...	...	30°25	30°08	ENE	...	
	Mid-night.	...	...	30°24	30°07	ENE	...	
<i>Khiva</i>	Left Bombay for Singapore.							
	4 P.M.	...	...	30°10	...	...	...	Light winds; fine southerly swell.
	8 P.M.	...	...	30°14	...	SW	...	
	Mid-night.	...	...	30°14	...	SSE	...	Light airs and calms; SW swell.
<i>Akbar</i>	4 A.M.	...	...	...	...	Calm	...	Calm; fine clear weather.
	Noon	16° 34'	75° 34'	29°93	30°05	...	...	Smooth sea.
	4 P.M.	...	...	...	...	...	...	Light winds; fine clear weather and smooth sea.
<i>Jumna</i>	4 A.M.	...	...	30°09	30°05	NE	2 to 3	Sea smooth.
	8 A.M.	...	...	30°16	30°12	NE	1 to 2	
	Noon	13° 21'	48° 0'	30°15	30°11	...	...	

NAMES OF SHIPS.	Hour.	Position at Noon.		Barometer at Noon.		Wind at Noon.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Jumna</i> —contd.	4 P.M.	...	...	30°06	30°02	ESE	2	
	8 P.M.	...	...	30°05	30°01	E	1 to 2	
<i>Sierra Pedrosa</i>	8 A.M.	...	...	29°88	...	E	...	
	Noon	17° 3'	73° 26'	29°84	30°02?	SE	...	Light breeze and fine clear settled weather.
	8 P.M.	...	...	29°90	...	SSE	...	
<i>Waverley</i>	1 A.M.	...	...	...	...	NE	...	1 A.M., strong wind; heavy rain; 2 A.M., increasing wind and sea; thick rain; 4 A.M., heavy gale.
	6 A.M.	...	...	...	...	ENE	...	8 A.M., strong wind and heavy sea running.
	10 A.M.	...	...	...	...	E	...	10 A.M., weather clearer.
	Noon	18° 1'	69° 22'	30°00	29°97	E	...	Noon, strong wind and heavy rain; 4 P.M., strong breeze; weather clearer; 8 P.M., moderate wind and fine clear weather; midnight, light wind and fine clear weather.
<i>Regius</i>	1 A.M.	...	...	...	...	NE	...	Gentle breeze from NE springing up, with light northerly swell.
	4 A.M.	...	...	...	...	N	...	
	Noon	14° 56'	55° 49'	...	...	N	...	
	1 P.M.	...	...	...	...	N	...	1 P.M., moderate breeze and fine weather; 8 P.M., breeze freshening; midnight, fresh breeze and moderate sea.
<i>Henry Bolcknow</i>	1 A.M.	...	...	...	...	S	...	
	4 A.M.	...	...	29°96	29°95	...	...	Fresh winds and cloudy weather; confused sea from south and east.
	6 A.M.	...	...	...	...	SE	...	
	8 A.M.	...	...	29°97	29°96	...	...	Decreasing wind; confused sea.
	Noon	19° 29'	71° 8'	29°98	29°97	SE	...	Decreasing wind; confused sea.
	4 P.M.	...	...	29°94	29°93	SE	...	Moderate breeze and fair.
	8 P.M.	...	...	30°00	29°99	ESE	...	Decreasing wind; weather fine.
	Midnight.	...	...	29°99	29°98	ESE	...	Decreasing wind; weather fine.
<i>Commilla</i>	Noon	Left Bombay for Kurrachee.						
	4 P.M.	...	...	29°96	...	W	...	5 P.M., moderate southerly swell and light head wind.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Commilla</i> —contd.	6 P.M.	...	...	...	...	SW	...	
	8 P.M.	...	...	30'00	...	NW	...	8 P.M., light head wind and fine with strong southerly swell.
	Mid-night.	...	...	30'00	...	NW	...	Midnight, fine clear night; light airs and calms; strong southerly swell.
<i>Culna</i>	4 A.M.	...	...	29'90	29'96	SE	...	Fresh breeze and overcast.
	8 A.M.	...	...	30'03	30'09	S	...	Moderate breeze; fine weather; cloudy.
	Noon	17° 30'	72° 59'	29'97	30'03	SE	...	Light breeze and fine.
	4 P.M.	...	...	29'91	29'97	SE	...	Moderate breeze and clear.
	8 P.M.	...	...	29'94	30'00	E	...	Ditto.
	Mid-night.	...	...	29'96	30'02	E	...	Moderate breeze and fine.
<i>Java</i>	Left Kurrachee at 10 A.M.							
	Noon	24° 45'	...	30'17	30'04	Calm	...	Calm and fine.
	4 P.M.	...	...	30'15	30'02	Calm	...	Calm and clear.
	8 P.M.	...	...	30'17	30'04	Calm	...	Ditto.
	Mid-night.	...	...	30'15	30'02	WNW	...	Light breeze and fine.

The information contained in the logs of vessels navigating the Arabian Sea on the 12th is much larger in amount than hitherto, but it does not enable the centre to be determined with exactness at any time during the day. This appears to be partly due to the fact that, although the storm was increasing in intensity, it covered a much smaller area than in the Bay of Bengal, and barely influenced the weather at a distance of 150 or 200 miles from the centre. The wind directions and barometric readings indicate that the centre at noon was in about Lat. $16\frac{1}{2}^{\circ}$ N. and Long. 67° E. It had hence advanced a distance of about 170 miles, or at an average rate of 7 miles per hour.

The *Atrato* was nearest to the centre in the morning. She was in Lat. $18\frac{1}{2}^{\circ}$ N. and Long. $68\frac{1}{2}^{\circ}$ E. at noon, and hence in the north-east quadrant, at a distance of 150 miles. Heavy rain fell in the morning, but at noon the wind began to abate, and after a burst of heavy continuous rain in the afternoon the weather cleared up.

The *Waverley* was in Lat. 18° N. and Long. $69^{\circ} 22'$ E. at noon and steaming eastwards for Bombay. She was about 200 miles to the east-north-east at noon and gradually increasing her distance. In the early morning, when she was probably less than 100 miles to the north of the centre, she had strong winds and heavy rain. They increased in force until 4 A.M., when it blew a heavy gale. After this the weather gradually improved and she passed into fine clear weather in the afternoon. The *Rubattino* had advanced to the west of the cyclone, and was about 170 miles almost due west of the centre at noon, and was increasing her distance about 5 miles per hour. She had fresh north-north-east winds and an agitated sea, but the weather was in other respects fine.

All the remaining vessels were at distances of 300 miles and upwards from the centre during the day. They all experienced fine weather with light to moderate breezes. The agitation of the sea was the only indication of the distant disturbance. For example, the

Peshawar, which was in Lat. $15^{\circ}39'$ N. and Long. $57^{\circ}19'$ E., or 700 miles to the west at noon, had light breezes and fine clear weather throughout the day. The swell in the sea began to increase at 4 P.M., when she was at least 600 miles to the west of the centre.

13TH NOVEMBER (vide chart of day, Plate XX).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry	29'990	+ '029	+ '046	84'0	79	NE	2	40	1'15
Port Blair	29'918	— '056	— '026	82'7	87	NNE	4	59	...
Diamond Island	30'006	— '026	+ '035	87'4	84	NNE	3	35	...
Rangoon	30'000	— '026	+ '014	81'6	80	ENE	3	70	...
Akyab	30'026	— '014	+ '033	79'0	78	NNE	3	136	...
Chittagong	30'049	+ '003	+ '033	76'7	76	NE	1	31	...
Calcutta	30'049	— '011	— '003	79'5	74	WSW	2	69	...
Saugor Island	30'051	— '031	— '006	79'4	87	W	3	48	...
False Point	30'042	— '018	— '020	83'3	75	NNW	6	98	...
Gopalpur	30'038	— '010	+ '029	83'6	81	Calm	3	39	...
Vizagapatam	30'036	— '007	+ '024	83'5	69	W	0	0	...
Cocanada	30'035	— '014	?	81'5	75	NW	2	?	...
Masulipatam	30'029	— '008	+ '037	84'6	72	NE	2	34	...
Madras	30'052	— '002	+ '065	84'5	72	NNE	3	43	...
Negapatam	30'044	+ '014	+ '080	85'4	69	SW	7	135	...
Trincomalee	30'041	+ '023	+ '106	77'5	86	SW	8	119	0'20
Galle	30'069	+ '031	+ '131	78'0	91	S	4	111	...
Nagpur	30'039	0	— '004	82'7	39	NNE	4	148	0'03
Bombay	30'069	+ '016	+ '066	80'0	80	ESE	5	51	...
Patna	30'038	— '037	— '040	77'5	59	W	2	133	...
Allahabad	30'051	— '003	— '024	78'7	52	WSW	3	250	...
Lahore	30'022	— '042	— '027	75'1	37	W	1	71	...

The barometric changes during the preceding 24 hours in the land area of India were inconsiderable and did not alter the general distribution of pressure. The following are examples shewing the exceedingly small differences of pressure which obtained at this time over India:—

Madras	30'052 inches.	Calcutta	30'049 inches.
Allahabad	30'051 "	Peshawar	30'041 "
Bombay	30'069 "	Cochin	30'051 "
Colombo	30'063 "	Galle	30'069 "

Pressure was slightly lower in Burma than in India, but the difference was barely $\cdot 05$ ".

Winds were very irregular and unusually light over the whole country, but in the plains of North-Western India, the northern districts of Central India, Behar and Chutia Nagpur, a fairly steady westerly current was now established, and the air was very dry over the Punjab and the greater part of the North-Western Provinces. Skies were clear in all parts of India, excepting locally in some parts of the Madras Presidency, Assam, and Burma. With the exception of one or two light showers in Southern India and Ceylon, the day was rainless and the weather generally bright and clear. No rain fell at Port Blair in the Andamans, but rain in increasing amounts was received at Nancowry in the Nicobars, which registered 1.15 inches.

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Airlie</i> . . .	0° 1'	96° 8'	29.980	29.980	NW	4	Fine weather.
<i>Shahsada</i> . . .	4° 46'	100° 10'	30.000	29.970	NW	4	Light breezes and fine.
<i>Ballaarat</i> . . .	16° 23'	83° 48'	30.150	30.020	NE	2	Fine clear-weather throughout; smooth sea.
<i>Argo</i> . . .	Passing out of the Hooghly river.		30.187	30.032	N	1	S. E. swell.

The observations taken on board the ships and at the coast stations in the Bay indicate that light northerly or north-easterly winds were established over the whole of the Bay, and that they were steadier and stronger in the east and south-east of the Bay than elsewhere. Also rejecting the evidently erroneous barometric reading at Port Blair, the baric gradients were from north to south over the Bay, and larger in the Andaman Sea and the eastern half of the Bay than in the western. The *Shahsada*, entering the Andaman Sea from the Straits of Malacca on the south, had light breezes and very fine weather. The winds increased in force during the day as she advanced northwards. The *Airlie*, which crossed the Equator in Long. 96° E. during the day, had north-west winds of force 4 and fine weather. In the west and north-west of the Bay, fine clear weather prevailed throughout the day. Winds were barely half their normal strength at the Andamans and Nicobars. There were hence as yet no indications of stormy weather or of the existence of a barometric depression and cyclonic circulation in either the Andaman Sea or the Bay of Bengal.

Observations taken on board ships in the Arabian Sea.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Peshawar</i> . . .	4 A.M.	...	...	30.04	29.91	N	4	Moderate wind and fine.
	8 A.M.	...	...	30.04	29.91	N	5	Strong breeze and cloudy.
	Noon	16° 31'	60° 18'	29.95	29.82	N	6	Heavy swell.
	1 P.M.	...	...	29.83	29.70	N	7	Strong breeze and overcast; heavy squalls of wind and rain; high NE sea.
	2 P.M.	...	...	29.82	29.70	N	7	Increasing wind and sea.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Peshawar</i> —contd.	3 P.M.	...	...	29°82	29°69	N	8	
	4 P.M.	...	...	29°82	29°69	N	9	Strong gale with fierce squalls of wind and rain; mountainous sea.
	5 P.M.	...	...	29°82	29°69	NE	10	
	6 P.M.	...	...	29°82	29°69	NNE	10	5-20 P.M., heavy squall with blinding rain; winds of hurricane force.
	7 P.M.	...	...	29°77	29°64	NE by N	10	
	8 P.M.	...	...	29°76	29°63	...	10	Very fierce gale with blinding rain; frequent squalls of hurricane force.
	9 P.M.	...	...	29°48	29°35	ENE	11 & 12	High confused sea.
	10 P.M.	...	...	29°37	29°24	ENE	12	Heavy gale with blinding rain and terrific gusts of wind.
	11 P.M.	...	...	29°40	29°27	E	11	
	Mid-night.	...	...	29°50	29°37	E	11	Weather moderating slightly; fierce gale with continuous rain.
								Moderate breeze and fine, light breeze and fine.
<i>Henry Bolcknow</i>	4 A.M.	...	...	29°96	29°95	SE	...	
	Noon	20° 42'	68° 11'	30°00	29°99	...	...	
	8 P.M.	...	...	30°00	29°99	...	...	Confused swell; light winds and fine.
<i>Regius</i>	8 A.M.	...	...	...	...	N	...	Sea rising.
	Noon	15° 52'	59° 23'	...	...	N	...	Fresh breeze with high cross sea.
	Mid-night.	...	...	...	...	NW	...	Wind began to veer to west at 8 P.M.; squally, with rain.
<i>Jumna</i>	1 A.M.	...	...	...	...	NE	1 to 2	Sea smooth.
	8 A.M.	...	...	30°14	30°10	...	...	
	Noon	14° 23'	52° 24'	30°10	30°06	NE	1 to 2	
<i>Akbar</i>	Mid-night.	...	...	30°04	30°00	NE	1 to 2	
	1 A.M.	...	...	...	...	NW	...	Light breeze; fine and clear.
	8 A.M.	...	...	...	...	NE	...	
<i>Khiva</i>	Noon	14° 21'	73° 58'	29°94	30°06	NE	...	Calm and clear.
	Mid-night.	...	...	...	...	NE	...	Ditto.
	1 A.M.	...	...	...	...	S	...	Light wind and fine clear weather.
<i>Mecca</i>	4 A.M.	...	...	30°09	29°97	S	...	
	Noon	15° 26'	73° 35'	30°18	30°06	Var.	1 to 2	Light winds and fine clear weather.
	8 P.M.	...	...	...	...	Var.	...	Light variable airs and calms.
<i>Clan Sinclair</i>	1 A.M.	...	...	...	...	ENE	...	
	Noon	15° 22'	58° 7'	30°23	30°06	N	...	Moderate breeze and fine.
	4 P.M.	...	...	30°17	30°00	N	...	Fresh wind; heavy swell from ENE.
<i>Clan Sinclair</i>	8 P.M.	...	...	30°15	29°98	N	...	Strong wind and cloudy.
	4 A.M.	...	...	29°74	30°07	NE	...	Light breeze; fine clear weather; heavy NE swell.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Clan Sinclair</i> —contd.	8 A.M.	...	...	29.75	30.08	NE	...	Moderate breeze; fine and clear.
	Noon	15° 44'	57° 34'	29.72	30.05	N	...	
	4 P.M.	...	...	29.65	29.98	N	...	
	8 P.M.	...	...	29.68	30.01	N	...	Moderate breeze; heavy NE swell.
	Mid-night.	...	...	29.66	29.99	N	...	Moderate wind with heavy confused sea.
<i>Rubattino</i>	Noon	15° 58'	59° 44'	...	...	NNW	...	Strong breeze with heavy confused sea.
<i>Victoria</i>	1 A.M.	...	...	...	...	ENE	1	High sea.
	Noon	13° 47'	51° 10'	...	...	ENE	...	Light easterly airs and very fine clear weather.
								Ditto ditto.
<i>Java</i>	8 A.M.	...	...	...	...	NE	...	Light winds and fine.
	Noon	25° 1'	62° 48'	30.22	29.99	...	...	Heavy SE swell.
	8 P.M.	...	...	30.22	29.99	...	...	Light airs and calms.
<i>Pemba</i>	4 A.M.	...	...	30.08	30.03	NE	...	Fresh breeze and fine.
	Noon	24° 30'	61° 8'	30.08	30.03	NE	...	Moderate breeze and fine.
	4 P.M.	...	...	...	...	ENE	...	Light breeze and fine with heavy SE swell.
	Mid-night.	...	...	...	...	...	...	Light breeze with heavy swell.
<i>Mobile</i>	7 P.M.	Left Bunder Abbas for Bombay.						
	Mid-night.	...	...	...	...	S	...	Light breeze and fine.
<i>Arabia</i>	Left	Bussorah at 2 P.M.		...	...	N	...	
	4 P.M.	...	...	29.72	...	N	...	Weather fine and cloudy.
	Mid-night.	...	...	29.81	...	N	...	Moderate breeze and falling sea.
<i>Peshwa</i>	4 A.M.	...	...	30.06	30.00	S	4?	Fine clear weather; moderate breeze and smooth sea.
	Noon	12° 26'	74° 48'	30.09	30.03	S	4?	Light variable winds.
<i>Atrato</i>	4 A.M.	...	...	30.32	29.92	ESE	3	Fine.
	Noon	18° 59'	72° 11'	...	...	Calm.	...	
<i>Sierra Pedrosa</i>	4 A.M.	...	...	...	...	ESE	...	Light airs and fine weather.
	Noon	18° 13'	72° 59'	29.94	30.05	E	...	Light variable airs with fine weather; hazy over land.
	Mid-night.	...	...	...	...	Calm	...	Calm, with fine weather.
<i>Golden Horn</i>	Noon	17° 1'	72° 46'	30.00	30.03	ESE	...	Light winds and fine clear weather throughout the day.

The S. S. *Peshwar* passed through the storm on the afternoon and evening of the 13th, and thus enables the position of the centre to be fixed with accuracy at that time. She had fine clear weather and a north-east swell throughout the 12th, on the noon of which day she was in Lat. 15° 39' N. and Long. 57° 19' E., and steering a little to the north of east. At 8 A.M. of the 13th the barometer (corrected) stood at 29.91". The weather was cloudy, and a strong breeze was blowing at noon (barometer 29.82"). The weather had a dirty appearance and heavy squalls of wind and rain began to come up. At 4 P.M. (barometer 29.69") it blew a strong gale, with fierce squalls of wind and rain and a

mountainous sea, and at 5-20 P.M. (barometer 29·69") heavy squalls with blinding rain of hurricane force passed over the vessel. The barometer began to fall rapidly at 8 P.M., when it was blowing a fierce gale with blinding rain and frequent squalls of hurricane force. The barometer fell until 10-30 P.M., when it stood at 29·24, and violent rain-squalls and terrific gusts of winds were experienced. The wind during this time shifted from north at 4 P.M. (force 9), to north-east (force 10) at 7 P.M., to east-north-east at 9 P.M. (force 11 and 12), and to east at 11 P.M. The ship was in lat. $16^{\circ} 31'$ N. and Long. $60^{\circ} 18'$ E. at noon. Her probable position at 10-30 P.M. (allowing for change of course and current) was Lat. $17^{\circ} 30'$ N. and Long. $62^{\circ} 30'$ E. The centre at that time lay due south at a distance of not more than 20 miles, and hence its position at 10 P.M. of the 13th was in Lat. $17^{\circ} 18'$ N. and Long. $62\frac{1}{2}^{\circ}$ E. approximately. The position of the centre at noon, as obtained by means of this position and the various observations and extracts from the logs, was probably in Lat. $17^{\circ} 30'$ N. and Long. 64° E. and hence the rate of advance of the centre at this time was increasing.

It should perhaps be noted that the observations of the next day show that the direction of motion of the storm began to recurve from west through north-west to north on the evening of the 13th. The Captain of the *Peshawar*, whilst judging quite correctly as to the position and previous direction of motion, was of course unaware of the recurvature. He changed the course of his vessel to north-west at 1 P.M., hoping to pass the storm in the outer gale circle, but was caught up by the storm and apparently involved in it longer than he would have been if it had been marching on a straight course.

No other vessel was within the storm area during the day. The nearest was the *Regius* in Lat. $15^{\circ} 52'$ N. and Long. $59^{\circ} 23'$ E. at noon, and proceeding eastwards to Bombay. She had fresh breezes with a rising sea during the morning, but did not experience any squalls until 8 P.M., when she was about 100 miles to the west-south-west of the centre. The remaining vessels all experienced fine clear weather, with light to moderate variable breezes or calms.

14TH NOVEMBER (vide chart of day, Plate XX).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	Wind.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29·980	—·010	+·036	81·0	87	SW	2	42	1·80
Port Blair . . .	29·949	+·031	+·005	80·2	92	NNW	4	59	1·91
Diamond Island . . .	29·999	—·007	+·027	82·4	79	NNE	4	47	...
Rangoon . . .	30·005	+·005	+·018	82·1	86	ENE	3	70	...
Akyab . . .	30·036	+·010	+·040	80·1	73	N	3	136	...
Chittagong . . .	30·055	+·006	+·045	76·7	92	NNW	1	31	...
Calcutta . . .	30·076	+·027	+·024	77·5	55	NNW	3	103	...
Saugor Island . . .	30·066	+·015	+·011	79·4	70	NNW	4	63	...
False Point . . .	30·081	+·039	+·018	80·3	80	NNE	7	115	...

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Gopalpur	30'065	+0'027	+0'052	84'1	73	NE.	2	26	...
Vizagapatam	30'062	+0'026	+0'046	82'0	73	N	0	0	0'20
Cocanada	30'063	+0'028	?	81'0	81	ENE	4	?	0'22
Masulipatam	30'049	+0'020	+0'054	82'1	75	E	3	51	...
Madras	30'064	+0'012	+0'075	84'0	68	N	3	43	...
Negapatam	30'047	+0'003	+0'082	83'9	73	NW	2	38	...
Trincomalee	30'036	-0'005	+0'101	82'0	79	W	6	90	0'01
Galle	30'041	-0'028	+0'103	80'5	91	W	4	111	0'92
Nagpur	30'082	+0'043	+0'035	81'2	42	NNE	5	185	...
Bombay	30'106	+0'037	+0'101	80'0	85	SE	5	51	...
Patna	30'090	+0'052	+0'002	75'0	58	W	2	133	...
Allahabad	30'086	+0'035	+0'010	78'2	39	W	2	167	...
Lahore	30'044	+0'022	-0'010	73'6	42	Calm	1	71	...

A small increase of pressure, which was slightly greater in the western than in the eastern districts of India, had taken place during the preceding 24 hours. The chief feature in the distribution of pressure was the remarkably small barometric differences over the whole of India, excluding Burma. Pressure gave way very slightly in Ceylon and the Bay Islands and in South Burma, and hence probably over the Gulf of Martaban and east of the Bay of Bengal. In Upper India and the Gangetic Valley the winds continued to blow from the west or north-west, and the increased dryness of the air, due to these winds, extended eastwards into Bengal during the day. Fine weather with cloudless skies prevailed throughout Upper and Central India. Skies were clouded in the Madras coast districts, and some showers were received there. The weather was fine and skies clear in Burma.

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Airtie</i>	1° 28'	95° 41'	30'00	30'00	W	8	Light breezes and fine.
<i>Shahsada</i>	5° 33'	100° 15'	30'03	30'00	Var.	2 to 1	
<i>Nurjehan</i>	7° 26'	81° 55'	30'31	30'06	WNW	4	Smooth sea; cloudy weather.
<i>Walden Abbey</i>	7° 3'	91° 58'	30'14	30'00	WNW	6	Sharp squall at noon from NW. Weather squally at night.
<i>Argo</i>	18° 40'	85° 12'	30'196	30'041	NW	1 to 2	Morning, clouded in the east, where large water-spouts were seen forming; afternoon and evening, fine.
<i>Ballaarat</i>	20° 15'	87° 27'	30'16	30'03	NNE	2	Fine clear weather.

The observations of this day at the Bay Island observatories, and on board ships in the Bay, give the first indications of the changes which initiated the second storm of the series. The winds were very feeble at Nancowry and Port Blair and were barely half their normal force, but they had shifted to south-west at Nancowry and north-north-west at Port Blair. Rain continued to fall at Nancowry, and had extended to Port Blair during the previous day. The charted observations shew a slight tendency to diminished pressure and cyclonic circulation in the Andaman Sea.

The only vessel near that area at this time was the *Walden Abbey*. She was in latitude $7^{\circ} 3' N.$ and longitude $91^{\circ} 58' E.$, or a short distance to the south-west of Nancowry. Her log shows that the extension of rainfall to the Andamans accompanied the commencement of squally weather in that part of the Bay. She had a sharp squall at noon, and weather became more squally and unsettled towards evening.

The afternoon observations at Nancowry and Port Blair showed a considerable increase in the strength of the wind, and the commencement of squally weather, and confirm the log of the *Walden Abbey*.

Over the west and north of the Bay, the weather was fine and clear with light winds and a smooth sea. The *Argo*, in latitude $18^{\circ} 40' N.$, longitude $85^{\circ} 12' E.$, at noon, observed the formation of several large water-spouts to the east—a frequent indication and forerunner of the unsettled weather that precedes cyclones in the Bay.

Observations taken on board ships in the Arabian Sea.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Clan Sinclair</i>	1 A.M.	...	...	...	...	N by W	...	Moderate gale with heavy confused sea. Wind increasing and threatening a cyclone.
	4 A.M.	...	...	29.50	29.83	N by W	...	
	7 A.M.	...	...	...	...	W	...	
	10 A.M.	...	...	...	...	SW	...	
	Noon.	$15^{\circ} 35'$	$60^{\circ} 55'$	29.64	29.97	SSW	...	Fresh breeze and cloudy, with heavy confused sea.
	4 P.M.	...	...	29.62	29.95	...	...	
	8 P.M.	...	...	29.70	30.03	...	...	Fresh breeze and cloudy, but fine. Sea rough.
	Mid-night.	...	...	29.70	30.03	...	...	
	4 A.M.	...	...	30.04	29.87	N	...	Moderate wind; cloudy.
	8 A.M.	...	...	30.15	29.98	SW	...	Moderate breeze; heavy NNW swell.
<i>Mecca</i>	Noon.	$15^{\circ} 47'$	$61^{\circ} 27'$	30.15	29.98?	S	...	Ditto.
	4 P.M.	...	...	30.16	29.99	S	...	Moderate wind and cloudy.
	8 P.M.	...	...	30.21	30.04	S	...	Moderate wind.
	Mid-night.	...	...	30.19	30.02	S	...	Fine clear weather.

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NAME OF SHIP.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Feshawar</i>	1 A.M.	...	...	29°55	29°42	ESE	11	
	2 A.M.	...	...	29°65	29°52	ESE	10	
	4 A.M.	...	...	29°72	29°59	SE	10	4 A.M., strong gale with fierce squalls of wind and rain. Very high confused sea.
	8 A.M.	...	...	29°96	29°83	SE	9	8 A.M., decreasing wind and sea.
	11 A.M.	...	...	...	...	SE	7	
	Noon.	18° 4'	63° 41'	30°05	29°92	SE	6	Strong breeze and fine with passing clouds.
	4 P.M.	...	...	30°04	29°91	ESE	4	Moderate breeze and cloudy.
	Mid-night.	...	...	30°15	30°02	ESE	4	Fine clear weather.
<i>Jumna</i>	4 A.M.	...	...	...	...	NE	2	Sea smooth.
	8 A.M.	...	...	...	...	N	...	Heavy swell.
	Noon.	15° 12'	56° 59'	30°00	29°96	NW	2	
	8 P.M.	...	...	30°01	29°97	NW	2 to 3	
<i>Victoria</i>	Mid-night.	...	...	30°01	29°97	E	1	
	4 A.M.	...	...	30°00	30°01	E	1	Light airs and very fine clear weather; smooth sea.
	Noon.	14° 55'	55° 20'	29°94	29°95	NW	3	Heavy NE swell.
<i>Regius</i>	Mid-night.	...	...	29°90	29°91	W	2	Light breeze; heavy NE swell.
	1 A.M.	...	...	...	...	W to SW	...	Heavy confused sea; 6 A.M., winds moderating and sea more regular; 8 A.M., moderate breeze, cloudy overcast sky, passing showers.
	Noon.	16° 26'	62° 57'	...	...	S	...	
<i>Mobile</i>	2 P.M.	...	...	...	...	...	...	Wind falling light; sky clear; occasional showers; 9 P.M., gentle breeze and fine weather.
	2 A.M.	...	...	...	...	Var.	...	Light and variable airs and clear sky.
	Noon.	25° 20'	57° 50'	...	...	ESE	...	Light winds and fine.
<i>Fova</i>	Mid-night.	...	...	...	...	ESE	...	Light breeze and cloudy.
	4 A.M.	...	...	...	...	NW	...	Light winds and fine weather; heavy SE swell.
	Noon.	25° 5'	60° 15'	30°24	30°01	Calm.	...	Calm and fine.
<i>Pemba</i>	Mid-night.	...	...	30°23	30°00	...	...	Light airs and calms.
	8 A.M.	...	...	30°02	29°97	E	...	Fine clear weather.
	Noon.	25° 1'	63° 25'	30°09	30°04	N	...	Heavy swell. Light breeze and clear.
<i>Henry Bolcknow</i>	8 P.M.	...	...	30°08	30°03	ESE	...	Moderate breeze and cloudy.
	Mid-night.	...	...	30°10	30°05	ESE	...	Light breeze; sky overcast.
	4 A.M.	...	...	29°98	29°97	SE	...	Light breeze and fine.
	Noon.	22° 0'	65° 46'	30°01	30°00	SE	...	Ditto.
	8 P.M.	...	...	30°00	29°99	SE	...	Moderate winds; sky overcast.
	Mid-night.	...	...	29°98	29°97	SE	...	11 P.M., rain. Heavy swell.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Khiva</i> . . .	4 A.M.	...	...	30°14	30°02	Var.	1	Light variable airs and fine.
	Noon.	11° 50'	75° 9'	30°20	30°08	NW by N	2 to 3	Light winds and fine clear weather.
	4 P.M.	...	...	30°10	29°98	W	2	Light winds and fine.
	Mid-night.	...	...	30°18	30°06	WNW	3	
<i>Golden Horn</i> .	Noon.	17° 43'	72° 37'	30°00	30°08	S	...	Light winds; fine clear weather all day.
<i>Arabia</i> . . .	4 A.M.	...	...	...	...	NE	...	Fresh breeze and fine weather.
	8 A.M.	Anchored at Bushire				...	...	Moderate breeze and fine weather during day.

The position of the centre cannot be fixed with precision at noon of the 14th, as the nearest vessels were at greater distances than 200 miles from the centre. The observations when charted shew that the centre had recurved to the north and was probably in Lat. 18° 30' N. and Long. 60° 30' E. The *Clan Sinclair*, *Mecca* and *Regius* were all in front of the path of the centre on the 13th. They had strong winds early in the morning of the 14th, but in consequence of the change of direction of the storm, the weather rapidly improved. The *Clan Sinclair* in Lat. 15° 33' N. and Long. 60° 55' E. at noon had fresh breezes and cloudy weather, the *Mecca* in Lat. 15° 47' N. and Long. 61° 27' E., had moderate breezes and cloudy weather, and the *Victoria* in Lat. 14° 55' N. and Long. 55° 20' E. had light airs and very fine clear weather and a heavy swell from the north-east. The barometer in none of these vessels was below 29°95" (corrected) at noon. In other parts of the Arabian Sea, weather was fine and clear with calms or light winds.

15TH NOVEMBER (vide chart of day, Plate XXI).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29°957	—'023	+°013	81°0	78	SW	5	104	1°96
Port Blair . . .	29°835	—'114	—'110	79°2	91	N	6	85	1°31
Diamond Island . . .	29°967	—'032	—'006	81°4	83	NW	4	47	...
Rangoon . . .	29°915	—'090	—'073	83°6	78	ENE	4	93	...
Akyab . . .	30°001	—'035	+°002	78°5	74	N	3	136	...
Chittagong . . .	30°034	—'021	+°010	75°1	73	NNE	1	31	...
Calcutta . . .	30°060	—'016	+°019	75°5	56	NNW	3	103	...
Saugor Island . . .	30°079	+°013	+°035	77°4	61	N	5	79	...
False Point . . .	30°065	—'016	+°013	79°3	61	N	6	98	...
Gopalpur . . .	30°064	—'001	+°047	81°5	59	Calm	2	26	...
Vizagapatam . . .	30°060	—'002	+°040	80°5	59	NE	0	0	...
Cocanada . . .	30°060	—'003	?	80°0	78	NNE	6	?	...
Masulipatam . . .	30°041	—'008	+°043	85°1	66	NE	3	51	...
Madras . . .	30°057	—'007	+°066	77°0	91	ENE	3	43	0°23

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Negapatam . . .	30°045	—002	+079	84.4	71	NE	5	96	...
Trincomalee . . .	30°036	0	+100	77.0	91	NW	9	134	0.05
Galle . . .	30°021	—020	+083	80.0	93	W	8	222	...
Nagpur . . .	30°080	—002	+029	80.2	36	Calm	6	222	...
Bombay . . .	30°079	—027	+072	80.5	83	N	6	61	...
Patna . . .	30°092	+002	+015	74.5	48	SW	2	133	...
Allahabad . . .	30°070	—016	—007	77.2	42	SE	2	167	...
Lahore . . .	30°017	—027	—042	70.6	47	S	1	71	...

The barometer fell over the whole of India during the previous day. The changes in the India land area (excluding Burma) were small except in the Punjab. The fall of the barometer in the Punjab (averaging '05") accompanied a shift of the winds to east and the formation of cloud in the North-Western Himalayas and the adjacent districts of the Punjab. Winds were feeble in the Gangetic valley and Central India, but the predominant directions were west and north-west as they had been for some days previous. Fine clear weather prevailed over the whole of India, excepting in the Punjab and the southern districts of Madras. Some light local showers of no importance fell in South Madras.

The observations at the Bay Island stations and in South Burma show that a considerable decrease of pressure had occurred over the Gulf of Martaban and adjacent portions of the Bay. The fall exceeded a tenth of an inch at Port Blair. There was now a well-marked but small barometric depression to the east of the Andamans. Heavy rain fell at the Andamans, Cocos Islands and Nicobars during the previous 24 hours. Cloudy weather and rainfall had also extended to Diamond Island on the previous evening, so that it is certain that skies were now clouded over the Andaman Sea and more or less heavy rain falling. The winds were increasing rapidly in strength and were at 10 A.M. considerably above their normal force in November.

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Airlie</i> . . .	2° 57'	94° 48'	29.94	29.94	WSW	4	Fresh squally weather.
<i>Walden Abbey</i> . . .	7° 11'	91° 58'	30.09	29.95	WNW	4 to 7	Squally, with moderately high sea; 18 hours' continuous rain; evening, threatening weather.
<i>Shahsada</i> . . .	7° 49'	98° 12'	29.97	29.94	Var.	2 to 5	Morning, light breeze and fine; noon, fresh breeze and rain; evening, squally, with heavy rain.
<i>Khedive</i> . . .	8° 53'	69° 20'	30.10	30.04	Var.	1 to 3	Light airs and fine.
<i>Nurjehan</i> . . .	9° 43'	80° 40'	30.29	30.04	N by E	2	Cloudy weather and drizzling rain.
<i>Tibre</i> . . .	7° 9'	82° 10'	30.04	30.04	NNW	2	Fine weather; evening calm.
<i>Melpomene</i> . . .	8° 50'	70° 11'	30.32	30.05	SW	2	
<i>Argo</i> . . .	15° 42'	82° 12'	30.18	30.02	SE	2 to 3	Fine weather; slight swell.

It will be noticed that these observations confirm the conclusions derived from the land observations. The ship *Airlie* passed Acheen Head to the north of Sumatra during the day, and had fresh squally weather with south-west winds of force 4.

The *Walden Abbey* had advanced a very short distance during the previous 24 hours, and was about 120 miles south-west of Nancowry at noon. The winds (from west-north-west) increased in force from 4 to 7 during the day. The weather was squally and the sea rising. She had 18 hours' continuous rain during the day, and the weather at sunset looked very threatening. The *Shahzada*, advancing along the Malayan coast, experienced similar changes of weather. The winds were variable in direction, but increased in force from 2 to 5. The weather became squally in the afternoon, and heavy showers of rain fell.

The remaining ships' observations indicate that in the west and north of the Bay the weather was fine with light winds.

Observations taken on board ships in the Arabian Sea.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Regius</i>	1 A.M.	...	...	...	...	S by E	...	Light steady breeze; smooth sea.
	Noon	17° 26'	66° 42'	...	...	S	...	Light airs and calm.
<i>Mobile</i>	Mid-night.	...	...	...	...	Var.	...	Calm and smooth sea.
	1 A.M.	...	...	...	...	ESE	...	Light breeze and cloudy.
	4 A.M.	...	...	...	...	E	...	Moderate increasing wind, dull cloudy sky.
	10 A.M.	...	...	...	...	E	...	Fresh breeze, dark weather, and rain, thunder and lightning.
	Noon	24° 50'	61° 20'	30°00	29°96	E	...	1 P.M., passing squalls with rain; thunder and lightning.
	4 P.M.	...	...	...	...	E	...	Fierce squalls.
	5 P.M.	...	...	29°90	29°86	E	...	Strong gale and high cross sea.
	9 P.M.	...	...	29°15?	29°11?	NE	...	8-30 P.M., frequent and very fierce squalls.
	10 P.M.	...	...	29°20	29°16	NE	...	
	Mid-night.	...	...	29°40	29°36	N	...	Moderate gale; squalls less frequent and decreasing in force. High confused sea.
<i>Java</i>	8 A.M.	...	...	30°22	29°99	NE	...	
	Noon	25° 40'	57° 28'	30°21	29°98	Calm	...	Light airs and calm.
	4 P.M.	...	...	30°20	29°97	Calm	...	Light airs and fine.
	Mid-night.	...	...	30°20	29°97	Calm	...	
<i>Henry Bolcknow</i>	4 A.M.	...	...	29°94	29°93	SE	...	Fresh wind and fair.
	8 A.M.	...	...	24°94	29°93	ESE	...	
	Noon	23° 24'	61° 48'	29°86	29°85	...	...	Increasing winds and sea, passing heavy squalls. Rain.
	1 P.M.	...	...	29°82	29°81	SE to NE	...	Strong wind, and weather very threatening.

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NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Henry Bolcknow</i> —contd.	2 P.M.	...	...	29°80	29°79	SE to NE	...	Fierce gale; very heavy passing squalls; rain, thunder and lightning; very high confused sea. 4 P.M. to 4-45 P.M., hurricane; very high confused sea.
	3 P.M.	...	...	29°66	29°65	SE to NE	...	
	4 P.M.	...	...	29°36	29°35	SE to NE	...	
	5 P.M.	...	...	29°32	29°31	...	...	
	6-30 P.M.	...	...	29°82?	29°81?	W to NNW	...	5-30 P.M., decreasing wind; high confused sea.
	8 P.M.	...	...	29°82	29°81	W to NNW	...	Moderate wind; high sea.
	10 P.M.	...	...	29°88	29°87	W to NNW	...	Moderate wind; decreasing sea.
	Mid-night.	...	...	29°88	29°87	W to NNW	...	
<i>Clan Sinclair</i>	4 A.M.	...	...	29°72	30°08	S	...	Moderate breeze; fine clear weather; southerly swell.
	Noon	16° 54'	65° 4'	29°80	30°16	SSE	...	Fine and clear.
	Mid-night.	...	...	29°80	30°16	S	...	Light breeze and fine with passing clouds.
<i>Jumna</i>	4 A.M.	...	...	29°99	29°95	SE	1 to 2	Long swell from north-east.
	Noon	16° 24'	61° 28'	30°08	30°04	S	1 to 2	Moderate swell from north-east.
	4 P.M.	...	...	30°04	30°00	W	1	Slight swell.
	Mid-night.	...	...	30°10	30°06	SE	1	Light wind and fine.
<i>Mecca</i>	Noon	16° 48'	65° 9'	30°27	29°95	S	...	
	Mid-night.	...	...	30°28	29°96	Var.	...	Light airs and cloudy.
<i>Victoria</i>	4 A.M.	...	...	29°86?	...	W	2	Fine clear weather; light breeze.
	Noon	16° 0'	59° 18'	29°80?	...	W	2	Fine clear weather; light breeze.
	Mid-night.	...	...	29°90	29°98	SW	...	Light variable airs and fine clear weather.
<i>County of York</i>	Noon	15° 2'	56° 13'	30°16	30°03	Var.	...	Light winds; fine clear weather.
	Evening	...	...	...	...	NE	...	North-east swell.
<i>Khiva</i>	4 A.M.	...	...	30°10	29°95	NW	3	Moderate wind. Overcast with showers.
	Noon	8° 11'	77° 0'	30°17	30°02	NW	1 to 2	Light winds and fine.
	Mid-night.	...	...	30°10	30°95	Var.	1	Light winds; smooth sea; passing showers.
<i>Pemba</i>	4 A.M.	...	...	30°07?	...	Light variable airs.	...	Light airs and fine clear weather.
	Noon	Arrived at Kurra- chee.		30°04	30°02	...	...	Light breeze and fine.

The logs of two vessels, the *Henry Bolcknow* and the *Mobile*, enable the position of the centre to be fixed approximately at two different hours of this day.

The former vessel was proceeding to Bunder Abbas in the Persian Gulf. The weather was fine, but the wind began to increase at 8 A.M. She was in Lat. $23^{\circ} 24' N.$ and Long. $61^{\circ} 48' E.$ at noon. During the morning the weather became squally, and heavy squalls with much rain passed over the vessel between 11 A.M. and noon. The barometer began to fall rapidly at 1 P.M. It blew a fierce gale at 3 P.M. with very heavy squalls attended with rain, thunder and lightning and a high confused sea. The barometer fell five-tenths of an inch between 1 P.M. and 5 P.M., at which hour it was lowest ($29.31''$). The wind shifted round from east to north-west. The centre was then passing at a distance of not more than 20 miles to the east of the vessel, and hence in about Lat. $23\frac{1}{2}^{\circ} N.$ and Long. $62^{\circ} E.$ (allowing for the probable drift of the vessel). The barometer rose half an inch during the next hour and a half, and wind changed round through north-west to west, from which direction it was blowing at 6-30 P.M. From 4 P.M. to 4-45 P.M. it blew a complete hurricane with a very high and dangerous sea. The gig was lifted out of the davits and sails and awnings blown to pieces. The wind decreased very rapidly, and at 8 P.M. wind was moderate in force.

The following is an account of the storm as experienced on board this vessel which appeared in the *Bombay Gazette* :—

"At noon, on the 15th November, our position was Lat. 23.30 North, Long. 61.54 East, with a brisk south-easterly breeze. About an hour afterwards, the sky becoming suddenly overcast, the wind rising to a squall, and the rapidly falling barometer were ominous indications of the storm which was brewing, and which was soon to come down with terrific force upon us. The wind soon blew a gale, the rain fell in torrents, the sea was rapidly rising, and the ship was rolling fearfully. The ship, which was kept before wind and sea, was going full-speed, while the wind which was blowing with the force of a hurricane tore away some of the awnings. At half-past 4 in the afternoon the barometer read $29.32''$, the lowest point reached during the gale. The wind now shifted to the north-east, and the vessel got into the trough of the sea, when the helm was shifted to bring sea on the bow. We shipped several heavy seas, the steam pipes on the deck were broken, the tarpaulins were blown off the hatches, and the hencoops, with all their live stock, disappeared in a moment. Scarcely less severe were the ravages of the storm down below, where the tables and chairs were torn from their fastenings in the saloon, the medicine chest was broken open, and much damage was done to the furniture generally. On the deck the gig on the port side burst her lashings, and was lifted over the davits by the sheer force of the wind. The ship was in danger of having a hole bored in her by the broken davits, and to avert this catastrophe the engines were stopped for a time and then were made to go slow. At 6 o'clock in the evening the barometer indicated the turning point of the storm, the weather gradually cleared up. At this time, we were, as near as could be judged, equidistant between Ras-al-Had and Gwetter. Shortly afterwards the wind shifted from N.-E. to W., and then gradually to N.-N.-W., staying there. By 8 o'clock the weather became quite clear, and the steering gear having been set right we steered N. N.-W., the ship going slowly and steadily along her course, though the sea was still somewhat rough. The weather was fine, with a strong set of current down the Gulf of Oman, the wind blowing from the North-West. I may here remark that, during my thirty years' experience at sea, I never saw the wind and sea rise to such terrific force in so short a space of time, and eventually subside with equal rapidity."

The *Mobile* was proceeding from Bushire to Bombay. She passed out of the Persian Gulf on the morning of the 14th, and had fair weather with calms and light breezes throughout the day. At 4 A.M. of the 15th wind began to increase, and the sky clouded over, and at 10 A.M. rain began to fall; weather became squally at 1 P.M., and the squalls became more frequent and violent during the afternoon. At 3 P.M. it was blowing a steady gale from the east, and the barometer which was then at $29.87''$ began to fall rapidly. At

8-30 P.M. the squalls were very fierce and three boats were "blown to pieces." The barometer was lowest at 9 P.M. when it stood at 29.11". The wind was then at north-east and went round to north at midnight and north-west at 7 A.M. of the 16th. The position of the *Mobile* at noon of the 15th was Lat. 24° 50' N. and Long. 61° 20' E., and her probable position at 9 P.M. was in about Lat. 24° 25' N. and Long. 61° 55' E. The centre at that hour was at a short distance to the east, probably not more than 20 miles, and which was hence in about Lat. 24° 30' N. and Long. 62½° E. It was thus about 60 miles north of its position at 5 P.M., or was travelling at the rate of 15 miles per hour.

The observations taken on board these two vessels, it will be seen, corroborate each other. Each was about the same distance from the centre in the same quadrant (the west). The period of rapid fall of the barometer was 4 hours in each case and of a rapid rise in the case of the former, 4 hours. Hence it is probable that the inner disturbance or storm area was nearly circular in shape and radius a little over 60 miles. It therefore covered an area of diameter 130 miles.

It is not necessary to discuss the remaining abstracts from the logs of the other vessels, as they were all outside of the storm area on this day and had light winds and fine clear weather. The sea was smooth except in the neighbourhood of the disturbance, where there was a long swell from the north-east.

The extracts from the logs of vessels show that, except in the storm area itself and its immediate neighbourhood, the weather was fine with clear skies and light winds over the whole of the Arabian Sea. The evidence on this point is conclusive.

16TH NOVEMBER (vide chart of day, Plate XXI.)

10 a.m. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry	29.944	—0.13	—0.01	78.0	70	SW	11	210	1.72
Port Blair	29.739	—0.06	—0.06	79.7	91	NNE	10	134	1.43
Diamond Island	29.906	—0.61	—0.68	82.4	75	ENE	8	94	...
Rangoon	29.950	+0.35	—0.39	87.6	71	ESE	5	116	...
Akyab	29.957	—0.44	—0.45	80.6	73	NNE	3	136	...
Chittagong	29.974	—0.60	—0.52	73.6	82	NNW	1	31	...
Calcutta	30.005	—0.55	—0.34	73.5	74	Calm	4	138	...
Saugor Island	30.017	—0.62	—0.40	74.4	81	NNW	5	79	...
False Point	30.021	—0.44	—0.34	75.4	56	NNE	7	115	...
Gopalpur	30.019	—0.45	—0.02	79.5	51	NNW	2	26	...
Vizagapatam	30.023	—0.37	—0.01	79.5	58	W	0	0	...
Cocanada	30.038	—0.22	?	76.5	59	N	7	?	...
Masulipatam	30.017	—0.24	+0.16	82.6	63	N	3	51	...
Madras	30.036	—0.21	+0.43	82.0	73	NNW	3	43	...
Negapatam	30.012	—0.33	+0.45	83.4	73	NNE	5	96	...
Trincomalee	29.992	—0.44	+0.55	80.0	89	W	5	75	0.10
Galle	29.907	—0.24	+0.59	80.0	91	NW	5	139	...
Nagpur	30.031	—0.49	—0.24	80.2	39	Calm	4	148	...
Bombay	30.046	—0.33	+0.37	80.5	85	NNW	11	111	...
Patna	30.080	—0.12	+0.05	75.0	62	NE	1	67	...
Allahabad	30.061	—0.09	—0.11	76.2	53	Calm	2	167	...
Lahore	30.071	+0.54	+0.07	63.7	57	SSE	2	143	...
Kurrachee	29.919	—1.17	—1.41	80.7	87	SSW	12	150	0.25
Quetta	24.669	—0.90	—1.05	61.4	33	SSE	2	67	...

During the previous 24 hours the barometer rose briskly in the North-West Punjab, and slightly over the remainder of the Punjab and in the North-Western Provinces. Pressure gave way in all other districts. The fall was large in Sind, and pressure was about a tenth of an inch below the normal pressure of the month on the Sind coast. Pressure also decreased rapidly at Port Blair and to a less extent at Nancowry and on the Burma coast, thus indicating the further development of the barometric depression and cyclonic storm in the Andaman Sea. Winds were from north-east in Southern India, where skies were partially clouded, and a few very light showers were recorded. The winds were easterly over the greater part of the Gangetic valley and in the Punjab, and skies were overcast at many of the Punjab stations and in Sind. Skies were cloudless and weather fine over the remainder of the Indian land area.

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Airlie</i> . . .	6° 39'	94° 37'	29'92	29'90	SW	4 to 6	Fresh SW breeze with hard squalls and heavy rain. Sea moderate. Sky overcast and weather threatening.
<i>Walden Abbey</i> . .	8° 38'	92° 2'	30'04	29'90	W	6 to 7	Heavy squalls with heavy head sea and dirty weather.
<i>Shahsada</i> . . .	11° 11'	97° 26'	29'95	29'92	S	4	Squally with heavy rain. Strong breeze. Sea rough.
<i>Khedive</i> . . .	8° 0'	74° 13'	30'10	30'04	NNW	4	Morning, moderate breeze and fine weather; evening, light variable breeze with occasional rain; squalls.
<i>Melpomene</i> . . .	7° 58'	74° 15'	...	...	NE	6	
<i>Nurjehan</i> . . .	Negapatam Roads		30'25	30'00	Var.	1	Fine clear weather; smooth sea.
<i>Tibre</i> . . .	11° 1'	79° 59'	30'04	30'00	Calm	0 to 1	Fine weather.

The barometer had fallen a tenth of an inch at Port Blair during the previous 24 hours, and was falling at all the coast stations round the Bay, the amount being greatest on the Burma and Tenasserim coasts, and the depression was hence deeper and more clearly marked than on the 15th. Heavy rain continued to fall at the Bay Islands, and cyclonic winds of indraught were blowing over the whole of the Andaman Sea.

The *Shahsada* was passing northward along the Tenasserim coast and was in the outer storm circle. Heavy rain fell during the greater part of the day, the wind increased in force from 4 to 6, and the sea became rough in the afternoon.

The *Airlie* advanced quickly before the south-west winds in the southern quadrant during the day, and passed through the channel between Sumatra and the Nicobars into the Andaman Sea, where she experienced hard squalls and heavy rain.

The *Walden Abbey* was proceeding at this time very slowly up the Bay against head winds to the south-west of the Andamans. She had stormy weather with frequent heavy squalls throughout the day.

A few light showers of no importance fell in Burma during the day. Port Blair registered 1'72 inches at 10 A.M. and Nancowry 1'43 inches.

The various observations hence establish that a barometric depression had formed and was increasing in intensity, the centre of which was probably about 50 miles to the west-south-west of Port Blair. Heavy rain was falling over the area of depression and to the

south. The depression was at this time almost stationary, but the observations of the next day show that the storm gained considerably in force during the afternoon and evening of the 16th and commenced to move northwards.

Observations taken on board ships in the Arabian Sea.

NAMES OF SHIPS.	HOUR.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Commilla</i>	4 A.M.	Anchored at Kurrachee		...	...	...	...	Strong breeze with heavy rain.
	Noon	...	...	30°10	29°84	SW	...	Moderate gale and squally.
	2 P.M.	...	...	...	...	...	...	Wind increasing to a strong gale with squalls.
	6 P.M.	...	...	...	...	N	...	
	8 P.M.	...	...	30°10	...	NW	...	Strong gale and dark night.
	Mid-night.	...	...	...	...	NE	...	Wind decreasing and hauling round to N.E.
<i>Mobile</i>	1 A.M.	...	...	29°50	29°47	N	...	Decreasing winds and sea.
	3 A.M.	...	...	29°60	29°57	NNE	...	
	4 A.M.	...	...	29°70	29°67	NNE	...	Fresh breeze and confused sea.
	7 A.M.	...	...	...	...	NW	...	Ditto ditto.
	Noon	23° 30'	62° 26'	29°80	29°77	NW	...	Moderate breeze and fine weather.
	8 P.M.	...	...	...	...	...	...	Light breeze and fine weather.
<i>Henry Bolcknow.</i>	Mid-night.	...	...	29°85	29°82	NW	...	Ditto ditto.
	2 A.M.	...	...	29°88	29°87	NNW	...	Decreasing wind with confused sea.
	8 A.M.	...	...	29°90	29°89	NNW	...	Moderate breeze with fine weather. Sea moderate.
	Noon	23° 46'	59° 48'	29°96	29°95	WNW	...	Ditto ditto.
	8 P.M.	...	...	29°95	29°94	WNW	...	Decreasing breeze with fine weather and smooth sea.
	4 A.M.	...	...	29°71	30°05	NNW	...	Freshening breeze; fine clear weather.
<i>Arabia</i>	8 A.M.	...	...	29°75	30°09	NNW	...	Moderate gale. High sea.
	Noon	27° 00'	52° 19'	29°77	30°11	NNW	...	Ditto ditto.
	4 P.M.	...	...	29°70	30°04	NW	...	Wind and sea moderating.
	Mid-night.	...	...	29°78	...	...	...	Fine clear weather.
	4 A.M.	...	...	30°07	30°03	SE	2	Light breeze and fine.
	Noon	17° 33'	66° 5'	30°11	30°07	Var.	1	Sea smooth.
<i>Fumna</i>	Mid-night.	...	...	30°10	30°06	NE	1	
	4 A.M.	...	...	...	...	S	...	Light variable airs and fine clear weather throughout the day.
	Noon	17° 7'	63° 44'	29°92	30°00	E	...	
	4 P.M.	...	...	...	...	NW	...	
	Mid-night.	...	...	29°94	...	NE	...	
	Noon	15° 50'	59° 24'	30°16	30°03	Var.	...	Light variable airs and clear weather; NE. swell. Wind increased slightly in force during the evening.
<i>County of York</i>								

The storm centre probably crossed the Beluchistan coast during the night of the 15th. The observations throw no more light on its existence, but it almost certainly broke

up a few hours afterwards. The barometer rose rapidly at Kurrachee and the Sind stations on the morning of the 16th, and the strong wind which had prevailed at that port decreased rapidly on the evening of the 16th, when fine clear weather again set in. At Quetta, although there were irregular barometric changes on the 15th, 16th and 17th, the weather remained fine and clear throughout.

The breaking up of the storm appears to have been accompanied by a considerable amount of irregular disturbance. The *Commilla*, lying at anchor off Kurrachee, had a strong gale with squalls in the afternoon which lasted for about 12 hours and then passed off, and was followed by fine weather. The *Arabia* in the Persian Gulf (Lat. 27° N. and Long. $51^{\circ}19'$ E.) had fine clear weather early in the morning. At 8 A.M. the weather freshened, and it blew a moderate gale with a high sea until 4 P.M., when the weather cleared up.

Neither of these disturbances was apparently the direct continuation of the cyclonic storm. The observations taken at the land stations in Upper India furnish no evidence of the passage of a depression into Sind or the Punjab on this day, and there is no evidence connecting the disturbance in the Persian Gulf beyond coincidence in time. The only explanation appears to be that they were small secondary disturbances which were due to, and followed the breaking up of the large disturbance.

Over the whole of the Arabian Sea, except in the immediate neighbourhood of Sind and Beluchistan, weather was fine and clear with light variable winds and a smooth sea.

17TH NOVEMBER (vide chart of day, Plate XXII.)

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29'860	—'084	—'085	79'0	88	SW	12 *	242	2'50
Port Blair . . .	29'649	—'090	—'298	78'5	92	WNW	6	84	0'30
Diamond Island . . .	29'875	—'031	—'101	78'9	82	ENE	18	212	0'03
Rangoon . . .	29'925	—'025	—'066	78'1	79	ENE	7	163	0'02
Akyab . . .	29'942	—'015	—'062	81'1	64	NE	3	136	...
Chittagong . . .	29'949	—'025	—'086	77'7	81	NE	1	31	...
Calcutta . . .	29'978	—'027	—'070	76'0	62	NNE	4	138	...
Saugor Island . . .	29'973	—'044	—'101	76'9	77	NNW	5	79	...
False Point . . .	29'982	—'039	—'092	77'3	69	N	8	131	...
Gopalpur . . .	29'992	—'027	—'033	79'5	54	Calm	2	26	...
Vizagapatam . . .	30'005	—'018	—'021	79'0	54	W	0	0	...
Cocanada . . .	29'988	—'050	?	76'0	58	NW	6	?	...
Masulipatam . . .	29'976	—'041	—'027	81'6	65	N	2	34	...
Madras . . .	30'012	—'024	+ '017	82'0	51	NNW	5	72	...
Negapatam . . .	30'005	—'007	+ '036	82'4	60	N	5	96	0'03
Trincomalee . . .	29'991	—'001	+ '053	80'5	93	N	10	149	...
Galle . . .	29'991	—'006	+ '053	81'5	87	SE	4	111	0'03
Nagpur . . .	29'997	—'034	—'060	80'2	38	NW	5	185	...
Bombay . . .	30'024	—'022	+ '013	80'0	82	NE	10	101	...
Patna . . .	30'039	—'041	—'053	75'0	62	NE	1	67	...
Allahabad . . .	30'035	—'026	—'034	74'7	45	ENE	1	83	...
Lahore . . .	30'115	+ '044	+ '048	63'2	83	SE	2	143	0'06

A rapid rise of the barometer in Sind and Beluchistan followed the breaking up of the storm which had passed across the coast of Beluchistan on the 16th. The rise at Kurrachee, during the previous 24 hours, was '11" and at Jacobabad and Quetta '10". Elsewhere in the Indian land area pressure was decreasing slowly. Northerly winds prevailed round the Head of the Bay and in the Indus valley, and easterly winds or calms in Upper India. In Central India the winds were irregular in direction. Skies had cleared in the North-West Punjab, but in the central and eastern districts of the Punjab and the adjacent districts of the North-Western Provinces they were overcast, and light showers of rain had fallen there and in Sind during the previous 24 hours. Over the remainder of the country the weather was fine and cool and skies cloudless.

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Tibre</i> . . .		At Pondicherry.		30°00	29°98	Calm.	0 to 1	Fine clear weather. Smooth sea. Fine clear weather.
<i>Nurjehan</i> . . .		• Ditto.		30°23	29°98	N	2	
<i>Khadive</i> . . .	Noon	7° 22'	78° 43'	30°02	29°96	NE	2 to 3	Variable airs and squally.
<i>Melpomene</i> . . .	...	6° 53'	77° 33'	30°25	29°98	Var.	...	
<i>Shahsada</i> . . .	Morning	...	...	...	...	Var.	...	Squalls with heavy rain.
	Noon	14° 58'	97° 22'	29°93	29°90	E	5	Fresh breeze and fine.
	Mid-night.	...	...	...	...	E	3	Light breeze and overcast.
<i>Airlie</i> . . .	Noon	10° 30'	95° 45'	29°80	29°80	SW	8	Barometer fell '14" from 8 A.M. to noon. Fresh unsteady breeze from south-south-west to west-south-west. Very heavy rain. Sea rising rapidly. 4 P.M., barometer 29°61. Weather very threatening.
								8 P.M., sky overcast. Wind south. High sea from south-west.
<i>Walden Abbey</i> . . .	Noon	9° 55'	91° 50'	29°90	29°76	W	6 to 7	Strong squalls. Very heavy sea. Five hours heavy rain.

The observations at the Bay Islands and on board the vessels in the Bay establish that the barometric depression was now developing into a violent storm. The barometer had fallen rapidly at Port Blair and on board the *Airlie*, which was passing up the Andaman Sea in the south-east and east quadrants of the storm on this day. It fell two-tenths of an inch on board the *Airlie* between 8 A.M. and 4 P.M. The centre at noon was, so far as can be judged from the observations, about 50 or 60 miles to east by north of Port Blair. The *Airlie* had very heavy rain during this morning with strong but unsteady winds. The weather became more threatening as day advanced. She was about 170 miles to the east-south-east of the centre at noon, and hence quite in the outer portion of the disturbance.

The *Walden Abbey* was at about the same distance to the south-west of the centre in Lat. 9° 55' N. and Long. 91° 50' E. She had westerly winds of force 6 to 7 throughout the day with frequent strong squalls and a very high sea and heavy rain for five hours.

The *Shahsada* had passed into the north-east quadrant and was about 350 miles to the north-east of the centre at noon. Squalls which gave heavy rain passed over the vessel

in the morning; but as she advanced northwards, the weather moderated as she approached the Gulf of Martaban, where she experienced easterly breezes and fine weather.

These observations hence show fully the general character of the weather in the Andaman Sea and the adjacent part of the Bay. The weather was squally and stormy as far north as Lat. 15° N., and heavy rain was falling over the greater part of the area of the disturbance, which hence rapidly increased in intensity during the day. The storm had commenced to march northwards, but as yet very slowly. The disturbance was of moderate dimensions, as it affected the weather very slightly at distances of 200 miles and upwards. It had however already modified the wind directions at the head of the Gulf of Martaban and in South Pegu (which had shifted from north-east to east-north-east or east). Over the greater part of the Bay of Bengal ordinary north-east monsoon weather obtained, and there were no indications of stormy weather in the Bay proper except in the neighbourhood of the Andamans and Nicobars, where strong humid west and south-west winds were established.

Observations taken on board ships in the Arabian Sea.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
Arabia . . .	4 A.M.	...	...	29.78	...	NW	...	Light airs and fine.
	8 A.M.	...	...	29.70	30.04	...	...	Light airs and calms.
Jumna . . .	Noon	$18^{\circ} 20'$	$70^{\circ} 31'$	30.05	30.01	NE	1 to 2	Light winds from north-east during day. Sea smooth.
Victoria . . .	Noon	$18^{\circ} 1'$	$67^{\circ} 58'$	29.94	30.02	NE	2	Light north-east breezes with fine clear weather during day.
County of York . .	Noon	$16^{\circ} 26'$	$62^{\circ} 56'$	30.16	30.03	NE	...	Light winds and clear. Sea smooth.
Mobile . . .	Noon	$22^{\circ} 9'$	$65^{\circ} 58'$	...	...	ENE	...	Light breeze and very fine.
	Mid-night.	...	...	...	...	NE	...	Moderate wind and clear sky.

The preceding extracts show that the weather was now fine and clear over the north-east of the Arabian Sea, or in the part over which the cyclonic storm had advanced during the previous five days. The sea was smooth, and winds were normal in direction (north-east) and of force 0 to 2.

18TH NOVEMBER (vide *chart of day, Plate XXII*).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29.931	+0.71	-0.14	83.8	68	SW	10	194	0.17
Port Blair . . .	29.773	+1.24	-1.76	71.7	94	SE	8	111	2.50
Diamond Island . .	29.866	-0.09	-1.12	78.9	72	ENE	20	235	...
Rangoon . . .	29.922	-0.03	-0.71	75.7	75	ENE	8	186	...
Akyab . . .	29.942	0	-0.64	78.5	65	NE	3	136	...
Chittagong . . .	29.949	0	-0.81	77.2	76	NE	1	31	...

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Calcutta	29.945	—'033	—'105	76.5	60	NE	3	103	...
Saugor Island . . .	29.957	—'016	—'108	76.4	75	NNW	5	79	...
False Point	29.959	—'023	—'104	79.3	51	N	6	98	...
Gopalpur	29.961	—'031	—'067	80.5	58	Calm	1	13	...
Vizagapatam	29.958	—'047	—'071	79.5	57	W	0	0	...
Cocanada	29.972	—'016	P	75.5	64	NW	5	P	...
Masulipatam	29.957	—'019	—'048	80.6	57	N	1	17	...
Madras	29.975	—'037	—'022	80.5	56	NW	2	29	...
Negapatam	29.970	—'035	—'001	81.9	51	NW	4	77	...
Trincomalee	29.951	—'040	+ '012	80.0	64	N	8	119	...
Galle	29.955	—'036	+ '016	80.0	87	NW	3	83	...
Nagpur	29.959	—'038	—'100	80.2	37	NNW	5	185	...
Bombay	29.984	—'040	—'028	79.5	85	ENE	10	101	...
Patna	29.984	—'055	—'100	75.0	62	N	1	67	...
Allahabad	29.985	—'050	—'090	76.2	49	SSE	1	83	...
Lahore	30.033	—'082	—'037	68.1	65	W	2	143	...

The barometer fell over nearly the whole of India during the previous 24 hours. The fall was large in Upper India, and pressure was very uniform over the greater part of the Indian land area. In Upper India the easterly winds which had prevailed during the slight disturbance of the previous three days began to give way to westerly winds, and skies were cloudless throughout the day over the whole of Northern India. They were clear or very slightly clouded in Central and Southern India.

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
Nurjehan	Noon	13° 32'	84° 49'	30.20	29.95	N	2	Smooth sea. Hazy, cloudy weather.
Melpomene . . .	Noon	5° 57'	81° 10'	30.23	29.96	...	...	
Argo	10 A.M.	9° 49'	81° 1'	30.10	29.95	N	2	Strong southerly current.
Airlie	Morning	...	...	...	...	...	...	Fresh gale. Heavy showers.
	6 A.M.	...	...	...	...	ESE	...	Gale freshening. Heavy rain.
	Noon	13° 45'	94° 50'	29.70	29.70	S	9	
	2 P.M.	...	...	...	...	ENE	...	Strong gale. Very heavy squalls with thick rain. Heavy sea.
	Midnight	...	...	...	...	ENE	...	Heavy gale. Hard squalls. Rain.
Walden Abbey . .	Noon	10° 25'	91° 58'	...	...	W by N	6	Squally. Five hours heavy rain.
Rhedive	...	Colombo	Harbour.	...	...	Var.	...	Light and fine.

The observations, when charted, show that the depression had intensified and begun to move slowly to the north. A considerable rise of the barometer had occurred at Port Blair (·12") and Nancowry due chiefly to the northward advance of the storm area and heavy rain continued to fall at Port Blair. The centre of the depression was in about Lat. 13° N. and Long. 93½° E. at noon. The log of the *Airlie* shows that she was being drawn towards the inner storm area during the day. She had a fresh gale with strong squalls and heavy showers during the morning. The wind increased to a strong gale with very heavy squalls and thick rain at 2 P.M. At midnight it was blowing a heavy gale with hard squalls and rain. She had the wind from south at noon, but it gradually moved round to east-north-east during the afternoon as she advanced northwards.

The *Walden Abbey* was 250 miles to the south-south-west. She had westerly winds of force 6 with squalls and a heavy swell. It rained for five hours during the day.

The remaining vessels were either entering the Bay or near the Bengal coast. They all experienced fine weather with light airs and a smooth sea.

19TH NOVEMBER (vide *chart of day, Plate XXII*).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea- level.	Change since previous day.	Variation from normal.	Tempera- ture at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to aver- age amount expressed as a percentage.	
Nancowry . . .	29·898	—·033	—·048	85·0	68	SW	7	140	...
Port Blair . . .	29·824	+·051	—·127	79·7	91	WNW	8	111	0·10
Diamond Island . . .	29·884	+·018	—·096	79·4	72	ENE	18	212	...
Rangoon . . .	29·949	+·027	—·046	77·6	72	ENE	8	186	...
Akyab . . .	29·959	+·017	—·049	78·0	61	NNE	3	136	...
Chittagong . . .	29·971	+·022	—·060	76·1	76	ENE	10	31	...
Calcutta . . .	29·983	+·038	—·065	75·5	62	NNE	2	69	...
Saugor Island . . .	29·982	+·023	—·078	76·9	67	NNE	3	48	...
False Point . . .	29·988	+·029	—·066	78·8	60	N	5	82	...
Gopalpur . . .	29·989	+·028	—·043	80·5	66	Calm	1	13	...
Vizagapatam . . .	29·977	+·019	—·054	78·0	65	N	0	0	...
Cocanada . . .	29·981	+·009	P	77·5	61	NE	4	P	...
Masulipatam . . .	29·960	+·003	—·047	81·6	58	N	2	34	...
Madras . . .	29·977	+·002	—·022	82·0	58	NW	2	29	...
Negapatam . . .	29·980	+·010	+·007	86·4	49	W	4	77	...
Trincomalee . . .	29·950	—·001	+·010	81·0	59	N	9	134	...
Galle . . .	29·962	+·007	+·023	78·5	93	Calm	5	139	...
Nagpur . . .	29·982	+·023	—·080	79·7	44	ESE	5	185	...
Bombay . . .	29·993	+·009	—·021	80·5	85	E	7	71	...
Patna . . .	30·016	+·032	—·071	76·0	53	N	1	67	...
Allahabad . . .	29·984	—·001	—·099	79·2	46	SE	1	83	...
Lahore . . .	29·987	—·046	—·086	71·6	56	W	2	143	...

The barometric changes of the preceding 24 hours were small in amount, and did not alter the distribution of pressure in the Indian land area to any appreciable extent. A slight fall occurred in the Punjab, which tended still more to equalize pressure, and the pressure differences on this day were exceedingly small. This is shown by the following readings :—

Lahore	29'987 Inches.	Negapatam	29'983 Inches.
Allahabad	29'984 "	Calcutta	29'983 "
Nagpur	29'982 "	Cocanada	29'981 "

In fact, over the greater part of the Indian land area the total barometric difference was less than a hundredth of an inch.

The winds were, as is usual during a period of uniform pressure, very feeble and somewhat irregular. Light northerly winds prevailed round the west coast of the Bay and in Central India, and westerly winds in Upper India. The weather was fine, skies clear, and the air much drier over the whole of Northern India.

Observations taken on board ships in the Bay of Bengal.

NAME OF SHIP.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day .
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Tenasserim</i>	Noon	Rangoon.		29'99	29'92	ESE	2	Overcast. Confused sea.
<i>Tibre</i>	Noon	15° 20'	82° 50'	29'98	29'96	NE	4	Hazy. Very fine weather.
<i>Nurjehan</i>	Noon	Masulipatam Roads.		30'23	29'98	NE	2	Smooth sea. Clear weather.
<i>Khedive</i>	Noon	6° 16'	81° 40'	30'00	29'94	Calm.	0	Light winds and fine throughout.
<i>Melpomene</i>	Noon	8° 12'	83° 1'	30'13	29'91	Var.	...	Slight sea.
<i>Walden Abbey</i>	Noon	10° 7'	91° 50'	29'94	29'84	WNW	4	Moderately heavy swell from north-west. Squally with rain.
<i>Airlie</i>	Noon	13° 7' (D. R.)	94° 39' (D. R.)	29'50	29'50	...	...	Increasing gale.
	1 P.M.	...	...	29'46	29'46	NE by N	...	Fierce gale.
	2 P.M.	...	...	29'40	29'40	NNE	...	Hurricane. Terrific squalls.
	3 P.M.	...	...	29'25	29'25	NE by N	...	Ditto.
	4 P.M.	...	...	29'18	29'18	NNE	...	Ditto.
	5 P.M.	...	...	28'91	28'91	N	...	Do. Tremendous squalls and terrific sea.
	5-45 P.M.	...	...	28'72	28'72	NNW	...	Ditto ditto.
	7 P.M.	...	...	28'85	28'85	SW	...	Ditto ditto.
	9 P.M.	...	...	29'11	29'11	SW	...	Ditto ditto.
	10 P.M.	...	...	29'22	29'22	SSW	...	Ditto ditto.
	Mid-night.	...	...	29'33	29'33	S by W	...	Ditto ditto.

The observations show that the depression had now grown into an intense and dangerous storm. The centre was at noon in about Lat. 14° N. and Long. $93\frac{1}{2}^{\circ}$ E., and entering the South Preparis channel and was nearly midway between Diamond Island and Port Blair (each of which was about 150 miles from it). The storm had advanced very slowly northwards during the previous evening and night, with an average rate of about 3 miles per hour, but was now curving westwards and adopting the usual track of storms in the Bay during the month of November, *viz.*, west-north-west. The storm was of very small dimensions, as the barometer at Diamond Island had risen slightly, although the storm had been advancing towards it. The concentration of the storm was also shown by the fact that rain had practically ceased at Port Blair and Nancowry, and had not extended northwards to South Burma. In fact, the area of heavy rainfall and probably of depression was apparently smaller than on the previous day.

The violence of the storm is proved conclusively by the experience of the *Airlie*, which was drawn within the inner storm area, and carried westwards with the storm through the South Preparis channel during the day, so that the captain found on the 21st, when the weather cleared up, that he was 130 miles to the north-west of his position by account, although he had allowed 4 knots an hour for drift and current during the storm. The *Airlie* was in the northern quadrant on the evening of the 18th, and was carried round to the west or advancing quadrant on the morning of the 19th. The centre passed over her at 5.45 P.M., and left her behind in the southern quadrant. Her log states that at 4 A.M. the sky was overcast, and hard squalls came up at frequent intervals. The barometer stood at 29.61" at 8 A.M. The gale increased steadily during the morning and the squalls became fiercer and were attended with very heavy rain. The barometer fell to 29.40" at 2 P.M. The wind blew with hurricane force at that hour and carried away the mizzen stay sail. At 3 P.M. it was blowing a cyclone with terrific squalls and a fearful sea. The barometer fell to 29.18" at 4 P.M. The squalls continued to increase in violence. At 5.15 P.M. it was blowing with great fury, and the squalls were of tremendous force with excessively heavy rain. At 5.45 P.M., when the wind was at north-north-west and the barometer at 28.72," there was a lull of about 10 minutes, when the vessel passed from the central area into the southern quadrant, and the wind blew from the west for some time with great fury and roaring like heavy thunder. The squalls were so violent and attended with such heavy rain that it was impossible to see the forepart of the vessel. The squalls were strongest at 11 P.M., and it was hardly possible to move on deck at that time as the cyclone blew with fearful force, and the rain seemed to come down in a solid mass. The barometer stood at that hour at 29.25."

The previous account is very interesting, as it shows fully the intensity of the storm at this period and of the rainfall near the centre.

The *Walden Abbey* was 300 miles to the south-south-west at noon and had squally weather with occasional shower; and westerly winds of force 3 and 4. She was, although in the southern quadrant, quite in the outskirts of the storm.

The logs of the remaining vessels show that over the whole of the Bay, except in the neighbourhood of the Andamans and Nicobars, the weather was fine and clear, and sea smooth.

The storm was hence on this day of comparatively small extent, the area of considerable barometric depression probably less than 150 miles in diameter, but within that

area winds of hurricane force were blowing. Excessively heavy rain is also known by the log of the *Airie* to have been falling at this period at and near the centre where the barometric height did not exceed 28·72".

20TH NOVEMBER (vide *chart of day, Plate XXII*).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29·976	+·078	+·029	87·0	72	SW	18	362	...
Port Blair . . .	29·770	-·054	-·182	78·7	93	W	7	96	0·86
Diamond Island . . .	29·908	+·024	-·074	77·4	80	E	24	282	0·11
Rangoon . . .	29·921	-·028	-·076	77·6	68	ENE	9	209	...
Akyab . . .	29·986	+·027	-·024	80·1	67	N	3	136	...
Chittagong . . .	30·004	+·033	-·036	76·7	71	NE	1	31	...
Calcutta . . .	30·030	+·047	-·014	75·0	66	NNW	2	69	...
Saugor Island . . .	30·047	+·065	-·017	76·9	67	NNE	5	79	...
False Point . . .	30·029	+·041	-·030	79·3	64	NE	6	98	...
Gopalpur . . .	30·028	+·039	-·007	81·5	62	NNE	2	26	...
Vizagapatam . . .	30·031	+·054	-·003	78·5	63	NE	1	38	...
Cocanada . . .	30·030	+·049	P	77·5	71	NE	7	P	...
Masulipatam . . .	30·009	+·049	0	82·6	63	E	2	34	...
Madras . . .	30·016	+·039	+·015	82·5	65	N	4	58	...
Negapatam . . .	29·991	+·011	+·016	82·4	74	NW	3	58	...
Trincomalee . . .	29·968	+·018	+·026	81·0	69	N	9	134	...
Galle . . .	29·968	+·006	+·028	81·0	81	NW	5	139	...
Nagpur . . .	30·030	+·048	-·034	80·2	53	Calm.	4	148	...
Bombay . . .	30·016	+·023	+·001	81·0	81	E	10	101	...
Patna . . .	30·075	+·059	-·024	76·5	61	NE	0	0	...
Allahabad . . .	30·050	+·066	-·039	76·2	56	E	1	83	...
Lahore . . .	30·058	+·071	-·018	72·1	60	W	2	143	...

The changes of pressure in the Indian land area were still independent of the cyclonic depression in the Bay. The barometer had risen quickly during the preceding 24 hours in Northern and Western India and slowly in the Peninsula, and was slightly higher in North-Western India than elsewhere. Winds were everywhere light, and generally normal in direction in the land area. The weather was fine and skies clear throughout the day. The temperature and humidity of the air continued to decrease in Northern India with the persistence of cold weather conditions in Upper India.

Observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Airlie</i>	4 A.M.	...	...	29'42	29'42	S by E	...	Hurricane.
	6 A.M.	...	...	29'57	29'57	SSE	...	Very heavy gale.
	8 A.M.	...	...	29'68	29'68	SE by S	...	Ditto.
	10 A.M.	...	...	29'75	29'75	SE	...	Heavy gale.
	Noon	13° 35'	94° 38'	29'73	29'73	SE by E	...	Ditto.
	Evening	...	...	29'80	29'80	...	...	Moderate gale.
<i>Walden Abbey</i>	Noon	11° 57'	91° 29'	30'04	29'84 P	W by N	3	Very heavy north-east swell.
	Mid-night.	...	...	...	...	...	3	Three hours' heavy rain. Squally.
<i>Melpomene</i>	Noon	11° 31'	84° 26'	30'20	29'98	Var.	...	Squalls with rain.
<i>Khedive</i>	4 A.M.	...	...	29'90	29'84	NNW	2	
	Noon	10° 15'	81° 16'	30'02	29'96	N	...	Light airs and fine.
	8 P.M.	...	...	29'98	29'92	...	...	Moderate and gusty weather.
<i>Tibre</i>	Noon	18° 30'	85° 15'	30'04	30'02	NNE	3	Fine weather; feeble squall at 8 A.M. from ESE
<i>Nurjehan</i>	Masulipatam Roads.			...	...	E by N	2	Fine and clear; smooth sea.
<i>Tenasserim</i>	4 A.M.	...	...	29'81	29'74	ENE	4 to 6	Passing rain squalls. Heavy sea.
	Noon	16° 57'	92° 42'	29'97	29'90	ENE	4	Sea and wind moderating. Weather clear.
	8 P.M.	...	...	30'00	29'93	NE by E	4 to 5	Ditto.

The various observations when charted shew that the centre had recurved through an angle of nearly 60° and was now advancing to west-north-west across the centre of the Bay. The position at noon was in Lat. 14½° N., and Long. 92° 45' E., and hence about 145 miles to the south-west of Diamond Island. Strong easterly winds were blowing at that station, but hardly any rain fell at this time in the Bay Islands or South Burma. In fact the disturbance was on the 20th of very small area, but excessively violent. The *Airlie* was nearest to the centre on this day as on the 19th, but she passed beyond the outer storm circle during the afternoon. She was in the inner storm area until about 8 A.M., and experienced winds of hurricane force until 4 A.M. She had very violent squalls for some hours afterwards. It was blowing a fresh gale at noon with heavy squalls and rain, but the weather moderated rapidly during the afternoon.

The *Tenasserim* passed round the Alguada Reef and Cape Negrais into the Bay of Bengal early in the morning. She was then about 120 miles to the north-north-east of the centre, and had east-north-east winds of force 4 to 6 with heavy overcast skies and passing rain squalls. As she advanced to the north-west the weather improved rapidly, and at noon she had clear fine weather.

The *Walden Abbey* in Lat. 11° 57' N. and Long. 91° 29' E. or 200 miles to the south-south-west had moderate westerly winds with squalls and a very heavy north-east swell throughout the day. It rained violently for three hours.

The *Melpomene* and *Khedive* were advancing northwards near the west coast of the Bay for Calcutta. Both vessels had unsettled weather with variable unsteady winds and occasional squalls. In the north of the Bay weather was fine and clear.

The character of the disturbance is hence clearly seen on this day to be similar to what it was on the 19th. There was a small area of intense and violent cyclonic disturbance almost certainly not exceeding 150 miles in diameter. For some distance beyond this inner area weather was dull and overcast and squally, and beyond the outer area of squally weather, more especially to the north and north-west, weather was very fine and clear.

21ST NOVEMBER (vide *chart of day, Plate XXIII*).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 31" and sea- level.	Change since previous day.	Variation from normal.	Tempera- ture at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to aver- age amount expressed as a percentage.	
Nancowry . . .	30'016	+ '040	+ '068	87'0	69	S	12	232	...
Port Blair . . .	29'945	+ '175	- '009	81'9	86	SSE	7	93	...
Diamond Island . . .	29'990	+ '082	+ '006	77'4	89	ESE	3	365	2'15
Rangoon . . .	29'924	+ '003	- '075	85'6	65	ENE	8	186	...
Akyab . . .	30'014	+ '028	+ '002	79'5	72	NE	3	136	...
Chittagong . . .	30'035	+ '031	0	77'7	72	NE	1	31	...
Calcutta . . .	30'060	+ '030	+ '009	75'0	66	N	3	103	...
Saugor Island . . .	30'068	+ '021	- '001	76'4	68	NNE	4	63	...
False Point . . .	30'043	+ '014	- '024	78'3	68	NE	9	148	...
Gopalpur . . .	30'051	+ '023	+ '012	80'5	51	NNW	4	53	...
Vizagapatam . . .	30'034	+ '003	- '002	78'0	56	N	1	38	...
Cocanada . . .	30'033	+ '003	?	78'0	59	NE	7	?	...
Masulipatam . . .	30'019	+ '010	+ '007	82'6	61	NE	3	51	...
Madras . . .	30'039	+ '023	+ '036	81'0	71	N	6	87	...
Negapatam . . .	30'021	+ '030	+ '045	82'9	62	NE	8	154	...
Trincomalee . . .	29'986	+ '018	+ '043	81'5	75	NE	17	254	0'02
Galle . . .	29'970	+ '002	+ '030	82'0	83	SW	6	167	...
Nagpur . . .	30'089	+ '059	+ '023	77'7	41	NE	4	148	...
Bombay . . .	30'049	+ '033	+ '032	81'0	81	ESE	8	81	...
Patna . . .	30'128	+ '053	+ '034	76'0	66	Calm	1	67	...
Allahabad . . .	30'124	+ '074	+ '031	77'2	53	ESE	1	83	...
Lahore . . .	30'149	+ '091	+ '070	72'1	54	E	1	71	...

The barometer had continued to rise over the whole of the Indian land area during the previous 24 hours. The rise was large in North-Western India and small in amount elsewhere. The usual cold weather pressure conditions were again established over Northern India,—pressure being highest in the Punjab, and decreasing eastwards and southwards.

In Upper India the air motion was very slight, and along the west coast of the Bay the winds were generally from north-east, and hence practically normal in direction and character. Fine weather prevailed over the whole of the Indian land area, and the air was very dry in Northern and Western India. Temperature was slowly falling at this time in Upper India. No rain fell except a few light showers in the Carnatic and also in South Burma.

Observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Nowshera</i>	4 A.M.	...	...	29°70	29°82	ESE	6 to 7	Heavy squalls and high sea.
	Noon	18° 4'	91° 43'	29°84	29°96	E	6	Ditto ditto.
	8 P.M.	...	...	29°87	29°99	E by S	6	Overcast. Heavy south-east swell.
	Mid-night.	...	...	29°86	29°98	NE by N	6	Clearing up.
<i>Tenasserim</i>	Noon	19° 49'	88° 48'	30°06	29°99	N by E	3	Moderate sea.
<i>Tibre</i>	Do.	20° 57'	88° 7'	29°96	29°94	N	2	Squally in morning, fine weather afterwards.
<i>Nurjehan</i>	Do.	16° 35'	82° 23'	30°25	30°00	NE	4	Fine clear weather.
<i>Khedive</i>	...	Off Madras		29°98	29°92 ^p	NE	2	Light winds. Fine clear weather.
<i>Melpomene</i>	Noon	14° 45'	85° 30'	30°18	29°96	NE	4	Heavy sea from south-east.
<i>Airlie</i>	Noon	15° 2'	92° 35'	29°95	29°95	SE	...	Wind moderating.
	Mid-night.	...	...	...	...	...	...	Moderate breeze with beautiful clear weather.
<i>Walden Abbey</i>	4 A.M.	...	...	...	...	WNW	4	Heavy swell.
	Noon	14° 17'	92° 0'	30°10	29°90	SSW	4	Ditto.
	Mid-night.	...	...	...	...	ESE	5	Cross sea from south-east and west.
<i>Maharani</i>	4 A.M.	...	...	...	...	NE	Fresh	Fine but cloudy and high sea.
	8 A.M.	...	...	...	...	...	...	Heavy squalls.
	Noon	18° 13'	90° 22'	29°70	29°95	E	...	Fierce squalls. High sea.
	4 P.M.	...	...	29°65	29°90	E	Strong	Hard squalls.
	Mid-night.	...	...	29°70	29°95	SE	Do.	Weather very bad, with fierce squalls.

The history of the storm on the 22nd and 23rd shows that it was on these days as on the 19th and 20th,—a storm of small extent, but of great intensity. This was almost certainly also its character on the 21st. Its position at noon of the 21st can only be determined by observations taken on board ships in the outskirts of the storm. The probable position of the centre was in Lat. 15° 45' or 16° N. and Long. 90° 30' E., or about 180 miles to the west-north-west of its position at noon of the 20th, so that its average rate of motion during the previous 24 hours was between 7 and 8 miles per hour,—an unusually low velocity. The *Nowshera* was about 150 miles to the north of the storm centre at noon in Lat. 18° 4' N. and Long. 91° 43' E.; she had easterly winds of force 6 during the day with heavy squalls of wind and rain and a heavy swell from the south-east.

The *Maharani* was about 160 miles to the north of the centre at noon. She was proceeding on a south-easterly course from Calcutta to Port Blair, and passed from the north

to the east quadrant during the day. She had fine but cloudy weather in the morning with a confused sea. Squalls began to come up at 8 A.M. and became more frequent and fiercer. The wind shifted from north-east through east to south-east. In the evening she had hard squalls with much rain. The sea broke in all directions.

The *Airlie*, 150 miles to the east-south-east, had strong breezes, with occasional squalls in the morning. She sailed rapidly to the north-west, taking advantage of the favourable winds in the eastern quadrant, and had beautiful clear weather in the afternoon.

The *Walden Abbey*, 180 miles to the south-east, had moderate winds during the day. They backed from west-north-west to east-south-east, a change chiefly due to the westward movement of the storm. Over the north and west of the Bay, weather was still fine and clear. The heavy swell from the storm extended during the afternoon westwards as far as to the coast of Orissa and the Circars, and was the first indication of the approaching storm.

22ND NOVEMBER (vide *chart of day, Plate XXIII*).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	30°041	+°025	+°092	84°0	72	ESE	1	28	...
Port Blair . . .	29°996	+°051	+°040	82°3	79	SE	9	125	...
Diamond Island . . .	30°062	+°072	+°076	79°4	80	ENE	19	224	0°37
Rangoon . . .	30°081	+°157	+°080	79°6	99	ENE	5	116	...
Akyab . . .	30°084	+°070	+°070	79°0	78	E	2	91	...
Chittagong . . .	30°075	+°040	+°038	80°2	83	ENE	1	31	...
Calcutta . . .	30°092	+°032	+°040	77°0	62	NNE	4	138	...
Saugor Island . . .	30°084	+°016	+°022	77°9	58	NNE	8	127	...
False Point . . .	30°046	+°003	—°017	79°3	66	NE	15	246	...
Gopalpur . . .	30°039	—°012	—°003	77°5	61	NNW	5	66	...
Vizagapatam . . .	30°019	—°015	—°020	78°5	54	NW	0	0	...
Cocanada . . .	30°028	—°005	?	76°5	64	NW	8	?	...
Masulipatam . . .	30°029	+°010	+°015	80°6	56	N	2	34	...
Madras . . .	30°032	—°007	+°027	83°0	57	N	5	72	...
Negapatam . . .	30°012	—°009	+°034	83°4	60	NE	6	115	...
Trincomalee . . .	30°000	+°014	+°056	81°5	67	NE	11	164	0°43
Galle . . .	29°970	0	+°029	81°0	87	SW	4	111	...
Nagpur . . .	30°115	+°026	+°046	77°2	42	ENE	6	222	...
Bombay . . .	30°073	+°024	+°055	81°5	63	ENE	9	91	...
Patna . . .	30°164	+°036	+°079	75°5	64	NNE	1	67	...
Allahabad . . .	30°170	+°046	+°076	75°7	53	SE	1	83	...
Lahore . . .	30°213	+°064	+°131	72°6	48	N	1	71	...

A further considerable rise of the barometer occurred during the previous 24 hours over North-Western and Central India, thus emphasizing the high pressure conditions prevalent in that area. The barometer was steady in Bengal. The influence of the advancing depression in the Bay was now shown in the Indian land area by a very slight fall of the barometer in the Circars and Ganjam. The barometer had risen rapidly in Burma.

Normal winds prevailed over Northern and Central India. They were now increasing in force in the Bengal and Orissa Coast districts and the Northern Circars and bringing up much cloud.

Fine weather with clear skies prevailed in all other districts.

No rain fell in Burma, the Bay Islands, or in India, except light drizzling showers at some of the coast stations of the Northern Circars.

Observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Rewa</i> . . .	4 A.M.	...	...	29'94	29'96	N by E	5	Clear and fine.
	Noon	18° 20'	85° 20'	30'00	30'02	NNE	7	Moderate gale; high sea.
	4 P.M.	...	...	29'93	29'95	NNE	7	Moderate gale; high sea; showery.
	8 P.M.	...	...	29'94	29'96	NE	7	Hard squalls and heavy rain.
	Mid-night.	...	...	29'98(?)	30'00(?)	ENE	...	Hard squalls.
<i>Airlie</i> . . .	Noon	16° 21'	93° 42'	30'05	30'05	SE	3	Beautiful clear weather.
<i>Walden Abbey</i> . . .	Do.	17° 29'	92° 2'	30'19	30'05	ESE	3 to 4	Occasional squalls; fine weather.
<i>Maharani</i> . . .	4 A.M.	...	...	29'80	29'90	ESE	Strong.	High wind; rough sea.
	Noon	16° 57'	91° 21'	29'90	30'00	S	...	Weather moderating; high sea.
	4 P.M.	...	...	29'90(?)	30'00(?)	SE	Moderate.	Weather clearing; moderately light winds.
<i>Nowshera</i> . . .	(?)	21° 00'	88° 0'	29'91	30'05	NE by N	5 to 6	Overcast; fresh breeze.
<i>Tenasserim</i> . . .	Noon	At Saugor.		30'18	30'08	ENE	2	Weather gloomy at night with squalls and passing showers.
<i>Fibre</i> . . .	Do.	In River Hooghly.		30'00	29'98	Calm.	...	Fine weather.
<i>Nurjehan</i> . . .	Do.	17° 15'	82° 44'	30'27	30'02	NE	2	Heavy bank of clouds; sudden rain squalls.
	Mid-night.	...	...	30'18	29'93	N	7	
<i>Khedive</i> . . .	Noon	15° 6'	82° 32'	30'03	29'97	NNE	4	Light to moderate wind and fine weather.
	8 P.M.	...	...	29'96	29'90	N	5	Fresh wind; high sea.
	Mid-night.	...	...	29'90	29'84	NNW	5	Heavy sea; threatening weather, and every appearance of a cyclone.
<i>Melpomene</i> . . .	6 A.M.	...	...	30'15	29'93	NNW	6	Rough sea; drizzling rain.
	10 A.M.	...	...	29'90	29'68	N	7	
	Noon	16° 41'	86° 10'	29'85	29'63	ENE	8	Heavy gale.
	1 P.M.	...	...	29'80	29'58	N	9	Blowing very hard. Every appearance of bad weather to E.
	2-30 P.M.	...	...	29'65	29'43	NW	10	Fierce gale.
	3-30 P.M.	...	...	29'50	29'28	NW	11	Hurricane; ship covered with foam; heavy rain.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Melpomene</i> —contd.	4 P.M.	...	...	29'35	29'13	W	12	Hurricane.
	5 P.M.	...	...	28'95	28'73	SW	12	Ditto.
	6 P.M.	...	...	28'95	28'73	SW	12	Ditto.
	7-20 P.M.	...	...	29'00	28'78	SW	12	Ditto.
	8 P.M.	...	...	29'00	28'78	SSW	10	Ditto.
	8-30 P.M.	...	...	29'05	28'81	SSE	10	Ditto.
	9-40 P.M.	...	...	29'10	28'88	SE	10	Ditto.
	10-40 P.M.	...	...	29'15	28'93	ESE	10	Ditto.
	Mid-night.	...	...	29'20	28'98	ESE	11	Ditto.

These observations not only indicate fully the character of the cyclone on the 22nd, but also enable the position of the centre to be determined with approximate accuracy. The noon observations indicate that the centre was then in about Lat. $16^{\circ} 30' N.$ and Long. $87^{\circ} 30' E.$, and was advancing at a rate of 7 or 8 miles per hour. The *Melpomene* had steamed up the Bay for Calcutta to Lat. $16^{\circ} 41' N.$, and was almost directly in front of the cyclone at noon, and at a distance of about 70 miles. The barometer had fallen steadily but somewhat slowly during the morning and stood at 29'63" at noon. There was a very heavy sea, and skies were overcast and drizzling rain was falling, and weather looked very threatening to the east.

The wind shifted to N. at 1 P.M. and began to blow very hard. The barometer began to fall rapidly at 2 P.M., and it speedily blew a hurricane, which covered the ship with foam. The wind backed through W. to SW. at 5 P.M., when the barometer had fallen to 28'73". The ship's position at noon by dead reckoning was in Lat. $16^{\circ} 41' N.$ and Long. $86^{\circ} 10' E.$, and allowing for current, her position, when she was in the immediate neighbourhood of the centre at 5 P.M., was probably in Lat. $16^{\circ} 30' N.$ and Long. $86^{\circ} 45' E.$ She was then 5 or 10 miles to the south of the centre. Very heavy rain fell in the afternoon and during the night. The barometer rose very slowly after 5 P.M., and at midnight was only 28'98". This was due to the vessel drifting round the centre into the northerly quadrant and being carried forward with the cyclone by the force of the wind and current. The wind at midnight was from ESE, so that she had passed into the NE. quadrant of the cyclone. The wind continued to blow with hurricane force from ESE. for nearly twelve hours longer as will be seen in the account of the storm on the 23rd.

The *Rewa* was in the northern quadrant of the outer storm area. She was in Lat. $18^{\circ} 20' N.$ and Long. $85^{\circ} 20' E.$ at noon, or about 190 miles to the NNW. The weather during the morning was clear and fine, with fresh winds. At noon it blew a moderate gale with occasional showers and a high sea. As the squalls became more and more violent with heavy rain, the Captain changed his course to E. and thus passed round the inner storm circle to the north-east and east.

The *Khedive* was in Lat. $15^{\circ} 6' N.$ and Long. $82^{\circ} 32' E.$ at noon and hence advancing towards the path of the cyclone. The barometer began to fall slowly in the after-

noon and the wind to increase, and at 10 P.M. the weather was very threatening and cyclonic in appearance, and the Captain changed his course to east and remained for a few hours in the outer circle and then passed beyond it into fine weather on the 23rd.

The information contained in the remaining logs shows that over the north-west of the Bay a very heavy swell was now running, and rain-squalls were extending as far as the coast of Ganjam and the Northern Circars. The weather was fine in the north-north-east and east of the Bay. On the Burma and Arakan coasts bright clear weather was now established.

23RD NOVEMBER (*vide chart of day† Plate XXIII*).

10 A.M. observations (*chiefly at coast stations*).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	Wind.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	30°078	+°037	+°128	85°2	72	E	6	128	...
Port Blair . . .	29°932	—°064	—°026	88°2	64	ESE	8	111	...
Diamond Island . . .	30°088	+°026	+°100	80°9	74	NE	13	153	...
Rangoon . . .	30°120	+°039	+°117	80°6	54	ESE	0	0	...
Akyab . . .	30°122	+°038	+°106	81°1	72	NE	3	136	...
Chittagong . . .	30°121	+°046	+°111	79°2	83	NE	1	31	...
Calcutta . . .	30°130	+°038	+°076	77°0	71	NE	3	103	...
Saugor Island . . .	30°126	+°042	+°082	78°9	78	ENE	6	95	...
False Point . . .	30°084	+°038	+°038	77°3	86	E	15	246	0°13
Gopalpur . . .	30°038	—°001	—°008	75°5	90	NNE	9	118	0°55
Vizagapatam . . .	29°901	—°118	—°140	78°0	74	NE	2	77	0°10
Cocanada . . .	29°951	—°077	?	80°5	64	N	3	?	...
Masulipatam . . .	29°970	—°059	—°046	80°6	67	N	3	51	...
Madras . . .	30°022	—°010	+°015	81°0	54	NNW	5	72	...
Negapatam . . .	30°016	+°004	+°036	82°9	66	NE	6	115	...
Trincomalee . . .	30°008	+°008	+°062	80°0	78	E	7	104	...
Galle . . .	29°978	+°008	+°037	81°0	83	NE	3	83	...
Nagpur . . .	30°102	—°009	+°031	77°7	48	ENE	7	259	...
Bombay . . .	30°061	—°012	+°041	79°0	58	E	12	121	...
Patna . . .	30°196	+°032	+°123	78°0	63	E	1	67	...
Allahabad . . .	30°186	+°016	+°094	75°2	52	ENE	1	83	...
Lahore . . .	30°204	—°009	+°119	71°1	49	E	1	71	...

During the previous 24 hours pressure increased slightly in Bengal and Assam. No important change occurred elsewhere except on the coast of the Circars, where the barometer was falling rapidly in front of the approaching storm. The skies had clouded over in Southern Bengal, Orissa, and the Northern Circars, and rain was falling in light to moderate showers. The winds over a large portion of India were now influenced and

governed by the cyclonic disturbance. Easterly and south-easterly winds had set in over the Lower Gangetic plain, and were extending westwards up the Gangetic valley. A considerable fall of temperature had occurred over the Deccan and Central India during the past day.

Observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Nurjehan</i>	4 A.M.	...	...	30°10	29°85	N	7	
	8 A.M.	...	...	30°06	29°81	ENE	10	Heavy storm; terrific shifting squalls and very heavy rain.
	Noon	16° 56'	83° 56'	29°98	29°73	NE	10	Do. thick blinding rain.
	2 P.M.	...	...	29°03	28°78	NE	...	Ditto.
	4 P.M.	...	...	29°20	28°95	SE	9	Ditto.
	6 P.M.	...	...	29°52	29°27	SE	...	
	8 P.M.	...	...	29°80	29°55	S	9	
	Mid-night.	...	...	30°15	29°90	S	7	Weather moderating.
<i>Rhedive</i>	2 A.M.	...	...	29°83	29°77	NNW	5 to 6	Increasing wind and sea.
	4 A.M.	...	...	29°74	29°68	NNW	8	Fresh gale; hard showers of rain.
	7 A.M.	...	...	29°69	29°63	SW	8	Hard gale. High sea.
	10 A.M.	...	...	29°82	29°76	S by E	...	
	Noon	16° 55'	85° 23'	29°87	29°81	SE	6	Wind and sea moderating.
	4 P.M.	...	...	29°89	29°83	SE	6	Fresh wind; showery.
	8 P.M.	...	...	30°00	29°94	SE	5	Fresh wind.
	Mid-night.	...	...	30°02	29°96	E	4	Moderate wind.
<i>Melpomene</i>	0-40 A.M.	...	...	29°30	29°08	ESE	11	
	2 A.M.	...	...	29°15	28°93	...	12	Hurricane. Tremendous sea.
	3 A.M.	...	...	29°10	28°88	...	12	
	4 A.M.	...	...	29°20	28°98	...	12	
	6 A.M.	...	...	29°35	29°13	...	12	
	8 A.M.	...	...	29°50	29°28	...	10	Began to moderate.
	10 A.M.	...	...	29°60	29°38	...	9	
	Noon	17° 0'	83° 37'	29°75	29°53	...	8	Clearing.
<i>Rewa</i>	2 P.M.	...	...	30°15	29°93	...	...	
	4 P.M.	...	...	30°30	30°08?	...	...	
	4 A.M.	...	...	29°96	29°88	E by N	5	After 6 P.M. fine weather with an occasional squall. Strong gusts and rain.
	Noon	20° 5'	88° 26'	30°14	30°06	SE by S	5	Fresh breeze, with hard squalls.
<i>Walden Abbey</i>	8 P.M.	...	...	...	...	E by S	4	Fine clear weather.
	Noon	19° 158'	91° 48'	30°27	30°07	NE	2	Clear weather. Easterly swell.
<i>Airlie</i>	Mid-night.	...	...	...	...	NNW	1	Sea smooth.
	Off Cape Negrais	...	...	...	...	ESE	...	Fine clear weather.

The various observations when charted shew that the centre was in Lat. $16^{\circ} 45' N.$ or $17^{\circ} N.$ and Long. $84^{\circ} 30' E.$ at noon of the 23rd, so that it had advanced about 200 miles during the preceding 24 hours, or at the rate of nearly 9 miles an hour. The position and character of the storm are given with fullness and accuracy by the logs of the *Melpomene*, *Nurjehan*, *Rewa*, and other vessels which were involved in the storm during the day.

The *Melpomene* at midnight of the 22nd had passed into the NE. quadrant and was drifting westwards with the cyclone. The barometer at 0-40 A.M. had risen to $29.08''$. She then was apparently again carried towards the centre as the barometer fell gradually until 3 A.M. when it stood at $28.88''$, and the winds blew with hurricane force. She was for some hours at the mercy of the storm. Her boats were carried away and all the sails blown to pieces during the night, and at 7-30 A.M. the foremast went overboard. The barometer began to rise slowly at 4 A.M. and at noon had risen to $29.53''$. The weather commenced to clear at that hour and the winds to decrease in strength, and at 6 P.M. she passed into fine weather.

The next vessel, in order of time which was involved in the inner storm area, was the *Nurjehan*. She was coasting on her way from Galle to Calcutta. She had north winds, force 7, and a heavy cross sea at 4 A.M. The barometer fell an eighth of an inch between that hour and noon. At 8 A.M. she had terrific shifting squalls and ENE. winds of force 10 and thick blinding rain. She passed into the inner storm area at noon, and the barometer fell from $29.73''$ at that hour to $28.78''$ at 2 P.M., when it was lowest,—a conclusive proof of the small extent of the inner storm area, at least in the advancing quadrant. The wind shifted to SE. at 4 P.M., and the barometer began to rise rapidly and stood at $29.55''$ at 8 P.M. and $29.72''$ at 10 P.M. The position of the vessel at noon (by D. R.) was in Lat. $16^{\circ} 56' N.$ and Long. $83^{\circ} 56' E.$, and is apparently very nearly correct, so that the position of the storm centre at 2 P.M. was in about Lat. $17^{\circ} N.$ and Long. $84^{\circ} 15' E.$, or 220 miles west of its position at noon of the 22nd. It had hence advanced at an average rate of 9 miles per hour during this interval. The centre passed to the south of the *Nurjehan* at a distance probably not exceeding 5 miles.

The *Khedive* passed round the cyclone in its southern and eastern quadrants during the day. She was nearest the centre between 4 A.M. and 7 A.M., when the wind backed from NNW. to SW. and was of force 8. She had heavy squalls and hard showers of rain, and a very high confused sea. She was in Lat. $16^{\circ} 55' N.$ and Long. $85^{\circ} 23' E.$ at noon or 60 miles to the east of the centre, and had then occasional squalls with heavy rain. The weather rapidly improved in the afternoon as she passed northwards.

The experience of the *Rewa* was exactly similar. She also passed round the rear of the cyclone in the eastern quadrant, but at a greater distance than the *Khedive*. She had hard squalls with rain until noon, when she was in Lat. $20^{\circ} 5' N.$ and Long. $88^{\circ} 26' E.$

The remaining vessels were all outside the storm area and in the north-east of the Bay. They had fine clear weather throughout, with a moderate swell.

The preceding discussion has shewn that the storm at noon consisted of a very small inner area of rapid fall of the barometer and hurricane winds and blinding rain, and probably not more than 20 miles in width in the advancing quadrant and almost certainly not more than 50 or 60 miles in its entire width in the direction of its path. Beyond this was an area in which the barometer fell very slightly, but in which there were strong winds with

heavy squalls and much rain. The whole storm area was apparently not more than 150 to 200 miles in diameter in any direction. The winds were of course affected in direction to very much greater distances from the centre.

24TH NOVEMBER (*vide chart of day, Plate XXIII*).

10 A.M. observations (*chiefly at coast stations*).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Tempera- ture at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to aver- age amount expressed as a percentage.	
Nancowry . . .	30°038	—°040	+°087	84°4	72	E	8	152	...
Port Blair . . .	29°998	+°066	+°038	82°5	75	ENE	6	88	...
Diamond Island . . .	30°070	—°018	+°080	80°4	68	ENE	9	106	...
Rangoon . . .	30°083	—°037	+°078	80°1	65	ENE	5	116	...
Akyab . . .	30°089	—°033	+°071	80°6	75	NE	3	136	...
Chittagong . . .	30°079	—°042	+°050	80°2	81	W	1	31	...
Calcutta . . .	30°098	—°032	+°044	80°0	53	E	2	69	...
Saugor Island . . .	30°095	—°031	+°046	79°4	74	NE	3	48	...
False Point . . .	30°090	+°006	+°036	82°3	89	E	11	180	0°04
Gopalpur . . .	30°062	+°024	+°013	77°5	91	SE	11	145	5°24
Vizagapatam . . .	30°040	+°139	—°004	78°5	82	E	11	423	6°40
Cocanada . . .	30°008	+°057	?	76°5	82	ESE	9	?	0°32
Masulipatam . . .	29°974	+°004	—°044	81°6	78	SE	0	0	...
Madras . . .	30°019	—°003	+°010	84°0	64	SSW	3	43	...
Negapatam . . .	30°012	—°004	+°030	84°4	63	E	1	19	...
Trincomalee . . .	29°979	—°029	+°032	84°5	68	E	7	104	...
Galle . . .	29°964	—°014	+°022	82°5	89	NE	3	83	...
Nagpur . . .	30°022	—°080	—°051	78°2	63	ENE	8	296	...
Bombay . . .	30°003	—°058	—°018	78°5	63	ENE	10	101	...
Patna . . .	30°141	—°055	+°055	77°5	61	NE	1	67	...
Allahabad . . .	30°128	—°058	+°040	76°2	56	E	3	250	...
Lahore . . .	30°134	—°070	+°046	71°1	49	Calm	1	71	...

The 10 A.M. observations of the 24th show that the cyclonic storm which had crossed the coast of the Circars at midnight broke up as it advanced across the Eastern Ghâts. There was slight residual disturbance in the Deccan, but it was without a definite centre, and the cyclonic circulation was very feebly and indistinctly marked. The filling up of the cyclone had been accompanied with a general fall of the barometer over the whole of India, with the exception of those districts over which the storm had passed during the previous 24 hours, where it had risen rapidly. Very heavy rain had fallen on the coast of the Circars and Ganjam, and the skies were overcast at 10 A.M. in

that area. They were also clouded in Upper India due to some slight cold weather disturbance. The passage of the storm inland had given a slight increase of cloud to the Deccan Stations, but the cloud amount was very small, and the weather was described in the reports as fine with passing clouds. The following gives the rainfalls in the coast districts of Gangam and the Circars:—

Vizianagram	7'60 Inches.	Ganjam	3'80 Inches.
Vizagapatam	6'40 „	Aska	3'40 „
Gopalpur	5'24 „		

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Nurjuhan</i> . . .	Noon	16° 31'	84° 37'	30'26	30'01	E by S	2	Moderate NE swell and sea; sky dull, passing showers.
<i>Melpomene</i> . .	Noon	18° 46'	86° 05'	30'25	30'03	ESE	4	Fine weather and clear.
<i>Rewa</i> . . .	Noon	Off Garden Reach.		30'14	30'06	NE	2	Slight breeze and fine weather.
<i>Walden Abbey</i> .	Noon	20° 18'	91° 08'	30'26	30'06	NNW	1	Smooth water and fine clear weather throughout.
<i>Bancoora</i> . . .	Noon	16° 05'	86° 09'	30'05	...	E	4	Fine, clear.

These observations show that the stormy weather had passed away completely from the Bay and that fine weather was again established.

The Cocanada storm of November 1886 broke up completely as a barometric depression and cyclonic circulation on the evening of the 24th, and the chart of the 25th shows no trace of its existence. But, as frequently happens in the cyclonic disturbances of the transition periods which pass to the west coast, the circulation in the northern quadrant of the disturbance caused a considerable inflow of sea winds and therefore of aqueous vapour into Bengal and Orissa. Hence the skies clouded over, and more or less general rain occurred.

The distribution of the rainfall which occurs as an after-effect of these storms, depends partly upon the antecedent distribution of pressure and other conditions, but is generally confined to the coast districts in November and December. During the latter part of the south-west monsoon period of 1886 there had been a marked determination of the current to South Behar, and rainfall was unusually heavy in that area. The conditions favouring this indraught to South Behar had not yet passed away.

The disturbance in the Bay began to initiate the usual increase of humidity, temperature and cloud amount in South Bengal when it had advanced nearly midway across the Bay on and from the 21st. The breaking up of the storm was immediately followed by slight diffused disturbance in Bengal and Behar, and by a slight development of low pressure in Behar

relative to neighbouring districts. The indraught to this area gave moderate and fairly general rain to Orissa, Chutia Nagpur and South Behar on the 25th and 26th. Orissa received an average of 1·2 inches during this period, Chutia Nagpur 0·6 inch and South Behar 0·25 inch. The largest fall in Chutia Nagpur was 1·32 inches, and in South Behar 1 inch. The effect of this disturbance and influx of sea winds on the temperature, humidity and air motion of Bengal and Behar did not pass away until the 29th and 30th, when dry cool weather with westerly or northerly winds was again established over the whole of Northern India.

During this interval (*i.e.*, from the 25th to the 30th) the weather was fine with passing clouds over the whole of Southern India. A few light local showers fell in Southern India, as is usual during fine weather in the early north-east monsoon months. A very feeble, independent cold-weather disturbance gave overcast skies and light showers to the north-west districts of the Punjab on the 24th and 25th. Skies cleared on the 26th and pressure increased from that day to the end of the month. The meteorological conditions over the whole Indian area were approximately normal at the commencement of December. Skies were clear on the 1st over the whole of Northern and Central India and in Burma. Occasional light local showers were received on that day in the Nicobars and the Madras coast districts. The weather was fine and sea smooth over the whole of the Bay except in the extreme south, where strongish winds were blowing, and occasional rain-squalls formed and passed away.

No change of importance occurred on the 2nd, except that no rain fell in any part of India.

The history of the third storm is taken up from the 3rd December. The information respecting the meteorology of the Bay during the storm is unusually scanty, as the storm was of very much shorter duration than either of the previous, and there were very few vessels in the Bay at the time.

3RD DECEMBER.

10 A.M. observations (*chiefly at coast stations*).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29·887	+·035	-·072	83°0	74	NE	12	167	0·38
Port Blair . . .	29·953	+·023	-·023	83·7	78	NNE	7	100	...
Diamond Island . . .	30·042	+·033	+·034	78·6	75	NNE	8	105	...
Rangoon . . .	30·079	+·057	+·056	80·1	75	NNE	5	98	...
Akyab . . .	30·083	+·045	+·047	77°0	65	N	3	136	...
Chittagong . . .	30·108	+·061	+·042	72·6	64	Calm	1	30	...
Calcutta . . .	30·121	+·056	+·021	71·5	57	N	1	32	...

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	Wind.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Saugor Island . . .	30'112	+ '051	+ '016	71'4	76	N	3	48	...
False Point . . .	30'108	+ '050	+ '013	74'9	54	NE	5	79	...
Gopalpur . . .	30'098	+ '045	+ '017	76'5	60	NNW	3	41	...
Vizagapatam . . .	30'081	+ '036	+ '015	76'0	64	N	0	0	...
Cocanada . . .	30'072	+ '036	P	75'5	68	NE	7	P	...
Masulipatam . . .	30'040	+ '037	+ '001	79'1	60	N	3	48	...
Madras . . .	30'030	+ '031	— '008	73'0	86	NNE	7	92	1'90
Negapatam . . .	29'994	+ '033	— '003	76'8	90	NNW	7	103	1'12
Trincomalee . . .	29'969	+ '030	+ '011	77'5	86	N	7	77	0'39
Galle . . .	29'917	+ '019	— '029	80'0	85	E	2	65	2'06
Nagpur . . .	30'128	+ '071	+ '034	71'2	45	ENE	4	154	...
Bombay . . .	30'034	+ '042	— '001	77'5	61	E	10	101	...
Patna . . .	30'159	+ '080	+ '028	68'1	65	Calm	1	59	...
Allahabad . . .	30'150	+ '061	+ '032	68'6	47	WSW	1	71	...
Lahore . . .	30'119	+ '067	+ '003	68'1	43	E	2	133	...

During the previous 24 hours the barometer had fallen rapidly in Sind and the neighbouring districts. Elsewhere it was either steady or rising slowly. An area of low pressure was thus formed in Sind, which was governing the winds in Upper India. Over Bengal, Central and Southern India normal northerly or north-easterly winds prevailed. Skies which had been overcast for some days previously over a large portion of Southern India began to clear. One or two light showers of little importance fell on the Madras coast and in Ceylon. Elsewhere skies were clear and weather fine.

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
Mirzapore . . .	Colombo Harbour.		29'89	29'90	NE	2	Light breeze and fine.
Palitana . . .	13° 53'	85° 28'	30'07	30'00	NE	2	Fine; clear; moderate sea.
Dacca . . .	Madras Harbour.		30'17	30'02	NW	2	Light breeze; heavy showers.

The observations at the Bay Islands and coast stations show that on the 3rd north-east winds of moderate intensity prevailed. Winds were very light at the Ceylon stations, and there were no indications as yet of the existence of a depression in the south of the Bay. Rain was falling at Nancowry and in Ceylon, and it is probable that occasional rain-squalls occurred in the south of the Bay. The information from the logs of vessels is

extremely meagre, but so far as it goes, it proves that light north-east winds, force 2, prevailed, and that weather was fine and clear in the centre of the Bay.

4TH DECEMBER.

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29'858	—'029	—'102	80'0	81	E	13	183	0'29
Port Blair . . .	29'947	—'006	—'031	82'7	78	NNE	9	126	...
Diamond Island . . .	30'024	—'018	+ '014	76'9	73	NNE	6	79	...
Rangoon . . .	30'027	—'052	+ '002	85'1	47	W	4	78	...
Akyab . . .	30'069	—'014	+ '031	75'0	63	N	3	136	...
Chittagong . . .	30'102	—'006	+ '047	72'6	73	NE	2	61	...
Calcutta l. . .	30'123	+ '002	+ '035	70'5	68	N	2	65	...
Saugor Island . . .	30'118	+ '006	+ '027	71'4	71	SSW	6	97	...
False Point . . .	30'129	+ '021	+ '043	73'9	61	NE	6	95	...
Gopalpur . . .	30'123	+ '025	+ '039	78'5	54	NNW	4	55	...
Vizagapatam . . .	30'089	+ '008	+ '020	77'0	61	N	1	43	...
Cocanada . . .	30'076	+ '004	?	76'0	71	NE	12	?	...
Masulipatam . . .	30'045	+ '005	+ '004	80'6	62	NE	5	81	...
Madras . . .	30'033	+ '003	—'008	83'0	75	N E	7	92	0'47
Negapatam . . .	29'994	0	—'005	80'9	82	NE	7	103	0'21
Trincomalee . . .	29'940	—'029	—'020	81'0	83	NE	16	176	0'02
Galle . . .	29'920	+ '003	—'027	78'0	91	Calm	3	97	0'02
Nagpur . . .	30'155	+ '027	+ '058	72'7	41	ENE	3	115	...
Bombay . . .	30'064	+ '030	+ '028	79'0	53	NE	11	111	...
Patna . . .	30'183	+ '024	+ '058	67'1	59	W	1	59	...
Allahabad . . .	30'193	+ '043	+ '066	67'1	48	SW	1	71	...
Lahore . . .	30'217	+ '098	+ '098	64'7	49	N	1	67	...

The rise of the barometer which had commenced on the evening of the 2nd had extended to the whole country on the 3rd, and was large in amount over the whole of Northern and Central India. The barometer had begun to fall locally in the south-east of the Bay. The barometer was nearly 0'3" lower at Nancowry than at Balasore in Orissa, and 0'4" lower than in the Punjab, so that the baric gradients were steeper than is usual in the north-east monsoon. Winds were hence stronger than the normal on the Coromandel Coast and at the Bay Islands. The weather was cloudy in Southern India, and light showers fell generally in the coast districts. Rain also began to fall in increasing amounts at Nancowry.

Over the whole of Northern and Central India, and also in Burma, fine, clear cool weather prevailed, and the temperature was falling steadily with the continuance of dry land winds.

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Mirasapure</i> . . .	Colombo.		29°95	29°92	Calm	...	Calm in morning; light breezes in the afternoon.
<i>Palitana</i> . . .	17° 30'	86° 53'	30°15	30°08	N	3	Clear, fine. Smooth sea.
<i>Dacca</i> . . .	16° 4'	83° 14'	30°20	30°05	NE	6	Fresh to strong wind. Squally.

The observations of the 4th show that a slight fall of the barometer had occurred in the south-east of the Bay, and that the wind had shifted round to east at Nancowry. Rain had almost ceased to fall in Ceylon and on the Madras coast. Notwithstanding, winds were increasing in force in Ceylon and at the Bay Islands. Normal baric gradients continued over the whole of the Bay, and there is no evidence of the establishment of a depression on the morning of this day in the south of the Bay. The *Palitana*, passing up the centre of the Bay in Lat. 17° 30' N. and Long. 86° 53' E., had clear fine weather, light northerly winds and a smooth sea. The *Dacca*, 260 miles to the west-south-west, had fresh to strong winds and squally weather. She was near the coast of the Circars, and experienced the ordinary north-east monsoon weather of November and December.

5TH DECEMBER.

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29°808	—'050	—'153	80°0	86	NNE	16	226	1°83
Port Blair . . .	29°910	—'037	—'070	80°7	86	NNE	10	142	...
Diamond Island . . .	29°977	—'047	—'035	78°4	72	NNE	6	79	...
Rangoon . . .	29°924	—'003	—'103	74°2	76	NNE	7	137	...
Akyab . . .	30°017	—'052	—'023	70°9	76	NNE	3	136	...
Chittagong . . .	30°046	—'056	—'022	70°6	74	NNE	1	30	...
Calcutta . . .	30°088	—'035	—'003	68°5	60	N	4	129	...
Saugor Island . . .	30°078	—'040	—'017	68°9	75	SSE	9	145	...
False Point . . .	30°083	—'046	—'004	72°4	58	NE	7	111	...
Gopalpur . . .	30°096	—'027	+°008	75°5	64	Calm	5	68	...
Vizagapatam . . .	30°078	—'011	+°007	75°0	52	N	1	43	...
Cocanada . . .	30°068	—'008	?	75°5	60	NE	12	?	...
Masulipatam . . .	30°044	—'001	+°001	77°6	70	NE	6	97	...
Madras . . .	30°028	—'005	—'015	79°0	76	NNE	13	171	...
Negapatam . . .	29°962	—'032	—'039	80°4	81	NE	9	132	0°21
Trincomalee . . .	29°939	—'001	—'022	77°5	95	NE	19	209	0°81
Galle . . .	29°902	—'018	—'045	79°0	91	Calm	2	65	0°02
Nagpur . . .	30°152	—'003	+°053	71°2	37	NE	6	231	...
Bombay . . .	30°056	—'008	+°019	79°5	48	E	15	152	...
Patna . . .	30°096	—'087	—'036	71°0	53	W	3	176	...
Allahabad . . .	30°121	—'072	—'013	69°1	43	W	3	214	...
Lahore . . .	30°210	—'007	+°088	66°1	41	NW	3	200	...

A considerable fall of the barometer occurred during the previous 24 hours in the North-Western Provinces, Assam, Bengal, Burma and the Bay Islands, averaging '05". Elsewhere the changes were small and unimportant. If the Nancowry barometric observations be correct, the baric gradients in the Bay were much steeper than is usual in December. The most important feature in these observations was the heavy rainfall at Nancowry and the continuous increase in the force of the wind. Weather was apparently disturbed and squally in the neighbourhood. Over the centre and north of the Bay weather was fine. Skies were partially clouded on the Madras coast and light showers fell there and in Ceylon. The rainfall of the day was, however, small in amount as compared with that at the Nicobars.

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Mirzapore</i> . .	6° 14'	79° 57'	29.93	29.90	NE	2 to 5	Morning calm and fine; afternoon, moderate breeze and overcast.
<i>Dacca</i> . .	19° 32'	85° 57'	30.23	30.03	NE	4	Fresh wind; clear and fine.
<i>Palitana</i> . .	21° 58'	88° 11'	30.13	30.06	N	3	Fine clear weather.
<i>Tibre</i> . .	In the river Hooghly.		30.08	30.06	N	2	Fine weather.

A largish fall of the barometer had taken place over the east and north of the Bay and a smaller fall in and near the west coast districts. The baric gradients were considerably altered in amount by these changes, and the distribution of pressure slightly modified. Winds had reverted to their normal NNE direction at Nancowry, and N. to NE winds were now blowing at all the coast stations. Winds continued to strengthen at the Bay Island stations and at Trincomalee, but they were hardly stronger than would be expected from the gradients prevailing in the Bay at this time. Moderately heavy rain was falling at Nancowry, whilst rain had almost ceased to fall in Madras and Ceylon. The *Mirzapore*, passing round the south coast of Ceylon, had calm weather in the morning and moderate north-east breezes, force 5, with overcast skies in the evening. The *Dacca*, *Palitana* and *Tibre*, all near the head of the Bay, had fine clear weather, with light to fresh winds, force 2 to 4. It is thus certain that, although skies were overcast and rain-squalls may have occurred at this time in the extreme south of the Bay, there was as yet no barometric depression and no evidence of cyclonic circulation.

6TH DECEMBER.

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29.836	+0.28	-1.26	78.0	90	SE	16	224	1.43
Port Blair . . .	29.866	-0.44	-1.16	82.7	82	SSE	6	81	0.90
Diamond Island . . .	29.959	-0.18	-0.55	76.4	77	NNE	6	79	...
Rangoon . . .	29.968	+0.44	-0.61	77.1	78	NNE	6	118	...

STATIONS.	Barometer at 10 A.M. corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Akyab . . .	29°992	—°025	—°051	71°4	73	N	3	136	...
Chittagong . . .	30°018	—°028	—°052	70°1	74	NNE	1	30	...
Calcutta . . .	30°056	—°032	—°033	69°5	63	NW	3	97	...
Saugor Island . . .	30°078	0	—°032	70°4	66	NNW	6	97	...
False Point . . .	30°066	—°017	—°040	72°4	48	NE	8	127	...
Gopalpur . . .	30°082	—°014	—°009	73°5	46	NNW	4	55	...
Vizagapatam . . .	30°065	—°063	—°009	74°0	42	N	0	0	...
Cocanada . . .	30°060	—°008	?	72°5	58	NE	9	?	...
Masulipatam . . .	30°043	—°001	—°003	76°6	61	NE	4	65	...
Madras . . .	30°029	+°001	—°016	80°0	62	NNE	11	145	0°02
Negapatam . . .	29°972	+°010	—°031	75°3	87	NE	11	162	0°54
Trincomalee . . .	29°924	—°015	—°038	76°5	91	N	18	198	3°31
Galle . . .	29°889	—°013	—°059	77°0	95	NW	4	129	0°66
Nagpur . . .	30°135	—°017	+°034	73°7	34	ENE	6	231	...
Bombay . . .	30°052	—°004	+°013	77°0	53	E	10	101	...
Patna . . .	30°084	—°012	—°064	66°1	66	Calm	2	118	...
Allahabad . . .	30°094	—°027	—°045	68°1	32	NW	7	500	...
Lahore . . .	30°138	—°072	+°013	65°1	38	NW	3	200	...

The barometer had fallen very quickly in Sind, Punjab, and Rajputana during the previous 24 hours. Elsewhere the barometer was either steady or falling very slowly, and the baric differences were hence much smaller in Northern India. Winds were practically unchanged in direction, but were slightly feebler. Cloud began to form in the region of falling barometer in Upper India. Skies were clear in the Indian land area except in the Punjab, the southern districts of the Madras Presidency, and some parts of Burma. One or two very light showers fell in the coast districts of the Madras Presidency. With this exception the day was rainless in India.

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
Mirzapore . . .	7°50'	82°12'	29°90	29°87	NNE	6	Strong breeze ; overcast.
Tibre . . .	18°40'	84°50'	30°12	30°10	NNE	3	Fine.
Palitana . . .	In the River Hooghly.		30°10	30°03	NE	2	Fine.
Dacca . . .	Do.		30°19	30°04	NE	...	Light breeze ; clear.
Colaba . . .	Do.		29°98	30°03	N	2	Fine and clear.

The charted observations for the 6th shew that a depression had formed to the south-west of the Andamans, and that the winds had shifted round to SE. at Nancowry and SSE. at Port Blair. This was the commencement of the cyclonic circulation which developed rapidly into a small cyclone. The winds on the Coromandel Coast and the East Ceylon coast had commenced to back, and were blowing rather strongly. Rain continued to fall at Nancowry, and had extended to Port Blair. Heavy rain had also fallen at Trincomalee, and hence it is almost certain that rain in large amounts was now falling over the Bay to the south of Lat. 10° N. The information contained in the ships' logs gives little information respecting that part of the Bay. The *Mirzapore*, advancing along the east coast of Ceylon, had strong NNE. head winds of force 6 and overcast skies. The *Tibre* in Lat. $18^{\circ} 40'$ N. and Long. $84^{\circ} 50'$ E. had light NNE. winds of force 3, and the *Palitana*, *Dacca* and *Colaba* at the entrance of the River Hooghly had fine clear weather with light northerly breezes.

7TH DECEMBER (vide chart of day, Plate XXIV).
10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry . . .	29.921	+0.85	-0.42	81.0	87	SE	6	81	0.29
Port Blair . . .	29.880	+0.14	-1.04	79.7	86	ESE	20	282	0.30
Diamond Island . . .	29.995	+0.06	-0.21	76.4	66	NE	10	132	...
Rangoon . . .	30.029	+0.061	-0.002	77.1	71	NW	7	137	...
Akyab . . .	30.029	+0.037	-0.016	71.9	78	NE	2	91	...
Chittagong . . .	30.028	+0.010	-0.040	69.6	79	NE	2	61	...
Calcutta . . .	30.042	-0.014	-0.032	69.5	63	N	3	97	...
Saugor Island . . .	30.043	-0.035	-0.065	69.4	70	NNW	7	113	...
False Point . . .	30.051	-0.015	-0.050	72.4	55	NNE	6	95	...
Gapalpur . . .	30.047	-0.035	-0.048	74.5	47	NNW	4	55	...
Vizagapatam . . .	30.052	-0.013	-0.024	72.0	48	N	0	0	...
Cocanada . . .	30.047	-0.013	?	70.5	61	NNW	8	?	...
Masulipatam . . .	30.023	-0.020	-0.025	73.7	59	N	3	48	...
Madras . . .	30.026	-0.003	-0.021	74.0	68	NNW	10	132	...
Negapatam . . .	29.979	+0.007	-0.025	73.7	76	NE	10	147	...
Trincomalee . . .	29.914	-0.010	-0.050	79.0	74	N	25	275	0.02
Galle . . .	29.921	+0.032	-0.027	76.0	88	N	4	129	0.12
Nagpur . . .	30.133	-0.002	+0.029	74.2	33	NNE	6	231	...
Bombay . . .	30.056	+0.004	+0.016	78.0	46	ENE	13	131	...
Patna . . .	30.105	+0.021	-0.041	70.0	57	Calm	0	0	...
Allahabad . . .	30.132	+0.038	-0.011	64.5	53	Calm	2	143	...
Lahore . . .	30.127	-0.011	-0.001	66.1	41	N	2	133	...

The barometric changes during the previous 24 hours were generally small in amount, and the distribution of pressure in the Indian land area was practically unaltered. The large fall of pressure in Upper India during the preceding day was now followed by the setting in of easterly winds in the North-West Himalayas and at the submontane stations in the Upper Provinces, but elsewhere there was no perceptible change in the general character of the air movement in the land area.

The Bay observations shew that there was now a well marked depression extending between Ceylon and the Andamans. The winds at the west or Coromandel coast stations were backing round towards north-west under the extending influence of the depression. Skies were overcast in Southern India and slightly clouded in Burma and the Punjab, but no rain was reported in the Indian land area on this day. Temperature was falling rapidly in Upper India at this time, the fall in the 10 A.M. temperature averaging from 1° to 3° daily.

Observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Clive</i> . . .	Noon	6° 13'	81° 34'	29'93	29'88	NNW	3	Cloudy; sea smooth.
	8 P.M.	...	...	29'90	29'85	NW by W	5	Strong gale.
	Mid-night.	...	...	29'89	29'84	W by N	7	Hard squalls; confused sea.
<i>Mirsapore</i> . . .	Noon	11° 51'	81° 43'	29'97	29'94	NNE	6	Strong breeze and overcast.
	8 P.M.	...	...	30'00	29'97	NNE	5	Fresh breeze and fine.
	Mid-night.	...	...	29'98	29'95	NW	3	Light breeze and cloudy.
<i>Tibre</i> . . .	Noon	16° 10'	82° 20'	30'00	30'04	N	1	Calm; raining.
<i>Colaba</i> . . .	Do.	18° 30'	87° 10'	30'00	30'04	NNW	4	Fine and calm.
	Mid-night.	...	...	29'93	29'97	NE	4	Fine and cloudy.

The observations at the coast stations of the Bay shew that the barometer was rising in the east of the Bay and falling in the west. This was evidently due to the westward motion and extension of the area of depression which now stretched across from the Bay Islands to the coast of Ceylon. Rain fell in very small amounts in Ceylon and the Bay Islands, but no rain fell in Madras,—an indication that rain was now localized and falling only over the area of depression, and hence intensifying the cyclonic circulation and indraught. It is impossible to fix the centre of circulation with any precision, and it is probable that the circulation was ill-defined. The centre may have been in about Lat. 9½° N. and Long. 88° E.

The information given in the ships' logs is as hitherto very meagre. The *S. S. Clive*, which passed along the east coast of Ceylon, experienced increasing winds which backed from NNW. to W. by N. At 8 P.M. it was blowing a strong gale, and at midnight she had hard squalls and a high confused sea. The *Mirsapore*, approaching Madras, had fresh to strong breezes with fine weather. The *Tibre*, in Lat. 16° 10' N. and Long. 82° 20' E. had light northerly winds and calms throughout. The *Colaba*, in Lat. 18° 30' N.,

and steaming down the centre of the Bay, had fine weather and cloudy skies in the afternoon.

Hence the information is insufficient to enable the strength of the disturbance to be estimated at this time.

8TH DECEMBER (vide chart of day, Plate XXIV).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea- level.	Change since pre- vious day.	Variation from normal.	Tempera- ture at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to aver- age amount expressed as a percentage.	
Nancowry . . .	29'914	—'007	—'050	79°0	86	SE	11	159	1'59
Port Blair . . .	29'950	+ '070	—'036	78°7	81	ESE	19	268	0'50
Diamond Island . . .	29'995	0	—'023	77°4	67	ENE	19	250	...
Rangoon . . .	30°057	+ '028	+ '024	76°6	70	ENE	6	118	...
Akyab . . .	30°058	+ '029	+ '011	76°0	64	ENE	2	91	...
Chittagong . . .	30°073	+ '045	+ '006	73°6	73	NNE	2	61	...
Calcutta . . .	30°059	+ '017	—'025	72°0	64	SE	3	97	...
Saugor Island . . .	30°040	—'003	—'064	72°9	83	NW	7	113	...
False Point . . .	30°038	—'013	—'066	71°4	71	NNE	7	111	...
Gopalpur . . .	30°038	—'009	—'060	72°5	54	NNW	4	55	...
Vizagapatam . . .	30°028	—'024	—'051	74°0	43	N	0	0	...
Cocanada . . .	30°004	—'043	?	71°0	55	NNE	6	?	...
Masulipatam . . .	29'987	—'036	—'063	76°6	45	NE	3	48	...
Madras . . .	29'959	—'067	—'090	76°0	56	NNW	9	118	...
Negapatam . . .	29'938	—'041	—'068	71°7	66	NW	7	103	...
Trincomalee . . .	29'863	—'051	—'102	72°0	81	NW	17	187	...
Galle . . .	29'906	—'015	—'043	76°5	88	NNW	12	368	0'02
Nagpur . . .	30°063	—'070	—'043	69°7	38	NE	6	231	...
Bombay . . .	30°023	—'033	—'019	74°5	61	ENE	9	91	...
Patna . . .	30°125	+ '020	—'022	71°0	69	NE	0	0	...
Allahabad . . .	30°110	—'022	—'031	67°1	60	WNW	1	71	...
Lahore . . .	30°109	—'018	—'022	57°2	53	E	2	133	...

Pressure increased slightly during the preceding 24 hours in Burma, Assam and East Bengal. It fell elsewhere by unequal amounts, which were greatest on the Madras coast, to which the depression in the Bay was advancing. There was also an area of slightly diminished pressure in Northern India, which covered a large part of Rajputana and Central India. Easterly winds continued in the North-West Himalayas and the neighbouring plains. Calms were generally registered in the North-Western Provinces. Elsewhere winds were unchanged, except on the Coromandel Coast, where they were blowing strongly from the north-west. The slight disturbance in Upper India

gave increased humidity and overcast skies. Skies were thickly clouded in Southern India, and a few light local showers occurred during the day.

Observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Clive</i> . . .	Noon	8° 27'	82° 14'	29'81	29'76	W by N	9	Hard squalls, drizzling rain.
	4 P.M.	...	...	29'68	29'63	W	10	Strong cyclonic gales.
	8 P.M.	...	...	29'86	29'81	W by S	9	
	Mid-night.	...	...	29'91	29'86	W by S	6	
<i>Mirzapore</i> . . .	Noon	Madras.		29'96	29'93	NNW	4	Moderate breeze.
	Mid-night.	...	...	29'86	29'83	N	5	Fresh breeze; squally.
	4 A.M.	...	...	29'88	29'85	ENE	1	
<i>Tibre</i> . . .	Noon	...	...	29'84	29'89	ENE	4	Fresh breeze.
	Mid-night.	...	...	29'80	29'85	...	6	Squally.
<i>Colaba</i> . . .	Noon	15° 43'	85° 45'	29'95	29'98	NE	4	Cloudy; rain; squally.
	4 P.M.	...	...	29'81	29'84	ESE	4	Heavy rain; squalls.
	Mid-night.	...	...	29'89	29'92	ESE	9	
<i>City of Carthage</i> .	Noon	15° 42'	73° 14'	29'96	29'96	Calm	...	Sky clear.

The observations shew a further rise of the barometer in the east and centre of the Bay, and a fall on the west coast, due to the westward movement of the area of depression. The winds had backed round to north-west and north-north-west on the Coromandel Coast and the east coast of Ceylon. Strong winds continued to blow at Galle and the Bay Islands, indicating moderate indraught in the outer area of the depression. Showers fell in the Bay Islands, but elsewhere in the land area weather was dry and rainless during the day.^o The rainfall was evidently, as on the 7th, confined to the area of depression. The position of the depression is fixed by the observations taken on board of the ship *Panmure* (published in a Scotch newspaper), which passed through the storm during the day. The information is by no means perfect, but is very interesting, as it shews that the storm had now developed into an intense cyclone. She left the Sandheads on the 4th December, and proceeded down the Bay with fine weather and favourable north-east winds. The weather began to change on the 7th, and on the 8th she was, when in Lat. 10° 30' N. and Long. 85° E., involved in the cyclone. The ship was then under bare holes with the starboard side of the ship out of sight for 12 hours, the water touching the upper dead eyes of the lower rigging. The Captain expected the vessel to founder at any moment. At 2 P.M. the wind fell light and shifted from north-west to south-west, and commenced to blow harder than ever, so that it was impossible to move about upon deck. The barometer stood at 29'17" when lowest. At 7 P.M. the weather began to improve. All the livestock and moveables upon deck were washed away during the storm.

This gives the position of the storm very approximately at 2 P.M., and at noon its position was probably about 20 miles to the east-south-east.

The remaining vessels were all in the outer storm area. The *Clive*, in Lat. $8^{\circ} 27'$ N. and Long. $82^{\circ} 14'$ E. at noon, and therefore about 200 miles to the south-west of the centre, had severe squalls at noon and strong cyclonic gales of force 10 from the west. At 4 P.M. the weather began to improve. The *Colaba* was 350 miles to the north at noon, and had cloudy weather with rain-squalls during the afternoon. She approached the centre during the evening, and passed to the east of the cyclone at midnight, when she had strong east-south-east winds of force 9.

9TH DECEMBER (vide chart of day, Plate XXIV).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32" and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.			Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.	Ratio of amount of wind to average amount expressed as a percentage.	
Nancowry	30'001	+087	+036	82'0	79	SE	2	26	0'50
Port Blair	30'035	+085	+047	76'7	94	ESE	16	221	0'58
Diamond Island	30'074	+079	+054	77'4	67	E	20	263	...
Rangoon	30'068	+011	+033	76'1	61	ENE	7	137	...
Akyab	30'087	+029	+037	77'0	59	NE	3	136	...
Chittagong	30'097	+024	+029	74'6	71	NE	2	61	...
Calcutta	30'076	+017	—007	77'5	69	E	2	65	...
Saugor Island	30'070	+030	—040	77'4	82	ESE	3	48	...
False Point	30'044	+056	—069	77'3	86	NE	9	143	1'20
Gopalpur	30'017	—021	—085	71'5	85	NNW	7	96	...
Vizagapatam	29'954	—074	—127	74'0	81	NE	1	43	0'20
Cocanada	29'922	—082	?	73'5	88	NE	16	?	0'40
Masulipatam	29'880	—107	—172	70'7	90	N	5	81	0'46
Madras	29'734	—225	—317	66'0	97	NNW	18	237	0'25
Negapatam	29'896	—042	—112	65'4	89	NW	9	132	1'55
Trincomalee	29'870	+007	—096	73'5	93	NW	10	110	0'52
Galle	29'897	—009	—052	80'0	87	W	13	419	0'22
Nagpur	30'047	—016	—061	69'2	58	NNE	6	231	...
Bombay	30'001	—022	—042	75'0	58	ENE	11	111	...
Patna	30'142	+017	+010	68'5	73	ENE	2	118	...
Allahabad	30'130	+020	—007	69'6	66	ENE	2	143	...
Lahore	30'127	+018	—007	65'1	53	E	1	67	...
Cuddapah	29'974	—087	—116	65'9	79	?	?	?	0'03
Kurnool	29'976	—044	—097	69'2	63	?	?	?	...
Secunderabad	29'981	—052	—111	69'0	70	NNE	6	188	...

During the preceding 24 hours the barometer had risen slightly over the whole of Northern, North-Eastern and Central India. A rapid fall had taken place in Southern India, greatest in amount on the Coromandel Coast, due to the approach of the depression and cyclonic storm. Skies were overcast over the Madras Presidency, and heavy rain fell generally during the day in Southern India. The largest amounts were recorded in the coast districts to the north of the line of march of the centre. The following statement gives the most important:—

Aska	2.85 Inches.	Vizagapatam	1.00 Inches.
Ganjam	2.70 „	Bimilipatam	1.00 „

Winds over the greater part of Southern India and in Bengal were now more or less determined by the cyclone, and the easterly element predominated. The slight indraught due to the storm and the disturbance in Upper India gave cloudy skies over the whole of India, except Burma and Sind, where fine clear weather prevailed.

Observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	Hour.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
		Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Mirzapore</i> . .	Noon	Madras.		29.75	29.72	NNW	7	Moderate gale; hard squalls.
	4 P.M.	...	...	29.64	29.61	N	7 & 8	Fresh gale.
	Mid-night.	...	...	29.79	29.76	SSW	5 & 6	Strong breeze.
<i>Clive</i>	4 A.M.	...	...	29.88	29.83	W	4	Heavy bank of clouds.
	Noon	8° 29'	83° 17'	29.96	29.91	N	1	
	4 P.M.	...	...	29.84	29.79	E	2	
<i>Tibre</i>	8 A.M.	...	...	29.69	29.74	NNW	3	
	Noon	11°	80° 15'	29.74	29.79	NW	6	
	8 P.M.	...	...	29.84	29.89	WNW	5	
<i>Colaba</i> . . .	4 A.M.	...	...	29.81	29.84	SE	9	Heavy swell and rain.
	Noon	14° 21'	85° 42'	29.90	29.93	S	10	Ditto.
	4 P.M.	...	...	29.86	29.89	SSW	9	Ditto.
	Mid-night.	...	...	29.97	30.00	SE	4	Weather moderating.

The barometer had fallen very rapidly during the previous 24 hours on the Coromandel Coast. The barometer and wind observations when charted indicate that the centre was in the immediate neighbourhood of the Madras Coast. It was at 10 A.M., about 30 miles to the east of Madras and travelling in a direction N. 35° W. It had hence advanced about 350 miles since 2 P.M. of the 8th, or at a rate of about 17 miles per hour. The barometer at Madras stood at 29.73" at 10 A.M. and was then lowest. The wind was from the NNW but was by no means strong, the highest velocity not exceeding 26 miles per hour. Considering the intensity of the storm, as experienced by the *Panmure of Dundee*, it is evident that it had already commenced to break up, or was of unusually small dimensions. The centre crossed the coast about 30 miles north of Madras at noon and continued to advance during the day in the same direction as before. It passed

near Cuddapah late in the evening. The barometer fell to a moderate extent, but the rainfall was inconsiderable, and the storm of no great violence. The observer hence did not think it necessary to take any special observations, or send in a report of the weather during the storm.

The ship observations confirm the inference of the small extent and the decreasing intensity of the storm. The *Mirzapore* rode out the gale in the Madras harbour. The wind was strongest between noon and 4 P.M., but never exceeded a fresh gale. The *Clive*, in Lat. $8^{\circ} 29' N.$ and Long. $83^{\circ} 17' E.$ at noon, had light northerly winds of force 1 to 2 during the afternoon. The *Tibre*, in Lat. $11^{\circ} N.$ and Long. $80^{\circ} 15' E.$, a little south of Madras had NNW. to WNW. winds varying in force between 3 and 6. The *Colaba* continued to advance through the eastern quadrant and had winds of force 9 and 10 until 4 P.M., after which they rapidly decreased in strength, and before midnight light winds prevailed over the whole of the south of the Bay.

10TH DECEMBER (vide chart of day, Plate XXIV).

10 A.M. observations (chiefly at coast stations).

STATIONS.	Barometer at 10 A.M., corrected and reduced to 32° and sea-level.	Change since previous day.	Variation from normal.	Temperature at 10 A.M.	Humidity at 10 A.M.	WIND.		Ratio of amount of wind to average amount expressed as a percentage.	Rainfall during 24 hours preceding 10 A.M.
						Direction at 10 A.M.	Velocity in miles per hour for the preceding 24 hours.		
Nancowry	30°025	+024	+059	82°0	76	SE	2	29	...
Port Blair	30°055	+020	+065	82°2	80	ESE	8	110	0°55
Diamond Island	30°148	+074	+126	77°4	71	ENE	16	211	...
Rangoon	30°049	-019	+012	76°1	62	ENE	5	98	...
Akyab	30°133	+046	+080	75°0	77	NE	2	91	...
Chittagong	30°135	+038	+066	75°1	71	NE	2	61	...
Calcutta	30°131	+055	+058	76°0	66	ESE	3	97	...
Saugor Island	30°126	+056	+026	76°9	82	ESE	5	81	...
False Point	30°108	+064	+004	79°3	70	ESE	10	159	0°05
Gopalpur	30°072	+055	-033	76°5	90	ENE	8	110	3°85
Vizagapatam	30°043	+089	-041	76°5	84	N	1	43	1°00
Cocanada	30°002	+080	?	75°5	86	SE	23	?	0°49
Masulipatam	29°935	+055	-119	76°6	91	SE	13	210	0°86
Madras	29°958	+224	-095	75°0	77	SSW	13	171	0°45
Negapatam	29°934	+038	-076	77°3	75	WNW	6	88	0°21
Trincomalee	29°942	+072	-026	80°0	80	SW	3	33	0°09
Galle	29°986	+089	+036	78°0	89	W	15	484	0°22
Nagpur	30°044	-003	-067	74°2	76	ENE	7	269	...
Bombay	29°973	-028	-072	77°0	57	NE	10	101	...
Patna	30°159	+017	+037	74°5	70	NE	2	118	...
Allahabad	30°134	+004	-002	71°1	66	E	3	214	...
Lahore	30°154	+027	+017	66°1	54	SE	1	67	...

The depression had advanced across the Peninsula during the preceding 24 hours, and the centre was near Guntoor at 10 A.M. It had almost filled up, and the depression did not exceed '1" at that hour. A rapid rise of the barometer had hence occurred over the Coromandel Coast districts, and a slight fall on the Malabar Coast. Pressure had also risen quickly in Bengal and Burma, but elsewhere the changes were small. The skies were overcast or thickly clouded over the Peninsula, but the rainfall accompanying the storm, as registered at the rainfall reporting stations, was unusually small in amount.

The following were the heaviest rainfalls registered on the 10th :—

Gopalpur	3'85 Inches.	Nellore	1'20 Inches.
Masulipatam	1'78 "	Guntoor	1'00 "
Vizianagram	1'50 "		

Noon observations taken on board ships in the Bay of Bengal.

NAMES OF SHIPS.	POSITION AT NOON.		BAROMETER AT NOON.		WIND AT NOON.		Weather during the day.
	Latitude N.	Longitude E.	Actual.	Corrected.	Direction.	Force.	
<i>Mirzapore</i>	Madras.		29'96	29'93	S	2	Light breeze and fine.
<i>Glenmavis</i>	12° 17'	94° 38'	30'12	30'06	NE	...	Rainy.
<i>City of Carthage</i>	7° 57'	77° 14'	29'93	29'93	Calm.	0	Clear.
<i>Clive</i>	11° 29'	82° 12'	30'02	29'97	SE	2	Fine weather.
<i>Tibre</i>	6° 30'	80° 50'	29'91	29'96	Calm.	0	
<i>Colaba</i>	12° 27'	85° 3'	30'00	30'05	SE	5	Fine and clear.

The 10 A.M. observations indicated that the storm was rapidly breaking up. It completely disappeared before evening, and the weakness of the humid current at this time in the south of the Bay is fully shewn by the fact that, with the exception of a few local and very light showers, no rain fell during the remainder of the month. The south-west humid current retreated from the Bay, and immediately afterwards north-east winds were established over the whole of the Bay.

The following table gives the position of the centre of the first storm at the hours specified and its probable amount and rate of motion during the interval elapsed since the hour of the previous position :—

Day.	Hour.	PROBABLE POSITION OF CENTRE.		Distance passed over.	Rate of motion in miles per hour.
		Latitude N.	Longitude E.		
November.					
4	Noon.	10° 30'	91° 0'	...	...
5	Do.	11° 0'	90° 0'	75	3
6	Do.	11° 30'	88° 0'	150	6
7	Do.	12° 0'	86° 0'	150	6
8	Do.	12° 45'	84° 0'	150	6
9	Do	13° 30'	81° 0'	215	9

IN THE BAY OF BENGAL.

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Day.	Hour.	PROBABLE POSITION OF CENTRE.		Distance passed over.	Rate of motion in miles per hour.
		Latitude N.	Longitude E.		
November.					
10	10 A. M.	15° 30'	75° 30'	400	18
11	Noon	16° 0'	69° 30'	430	16½
12	Do.	16° 30'	67° 0'	170	7
13	Do.	17° 0'	64° 30'	170	7
	10-30 P. M.	17° 15'	62° 45'	120	12
14	Noon	18° 30'	60° 30'	180	12
15	Do.	22° 30'	61° 30'	360	12½
	5 P. M.	23° 30'	62° 0'	70	14
	9 P. M.	24° 30'	62° 15'	70	17

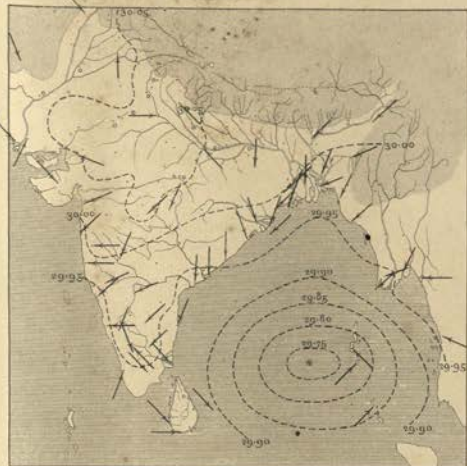
The following gives similar data for the 2nd cyclone :—

Day.	Hour.	PROBABLE POSITION OF CENTRE.		Distance passed over.	Rate of motion in miles per hour.
		Latitude N.	Longitude E.		
November.					
16	Noon	11° 15'	93° 30'	...	...
17	Do.	12° 0'	93° 30'	52	2
18	Do.	13° 0'	93° 30'	70	3
19	Do.	14° 0'	93° 30'	70	3
20	Do.	14° 30'	92° 45'	60	2½
21	Do.	16° 0'	90° 30'	180	7½
22	Do.	16° 30'	87° 30'	210	9
23	Do.	17° 0'	84° 30'	210	9
	2 P. M.	17° 0'	84° 15'	...	...

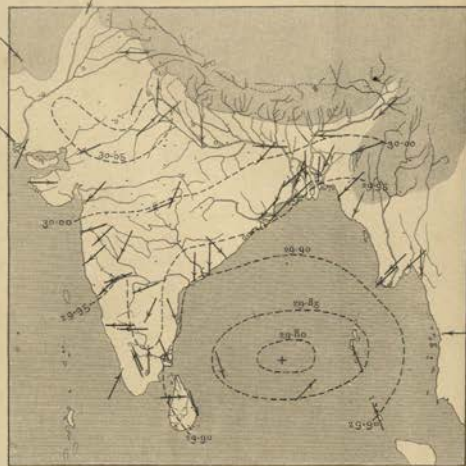
And the following furnishes similar data for the third cyclone :—

Day.	Hour.	PROBABLE POSITION OF CENTRE.		Distance passed over.	Rate of motion in miles per hour.
		Latitude N.	Longitude E.		
December.					
7	Noon	9° 15'	88° 0'	...	...
8	Do.	10° 30'	85° 15'	200	8
9	10 A. M.	13° 30'	80° 45'	360	16

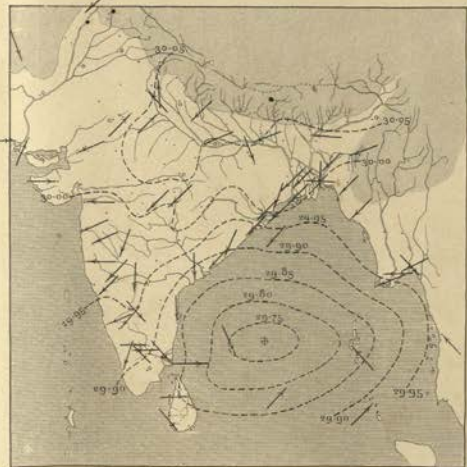
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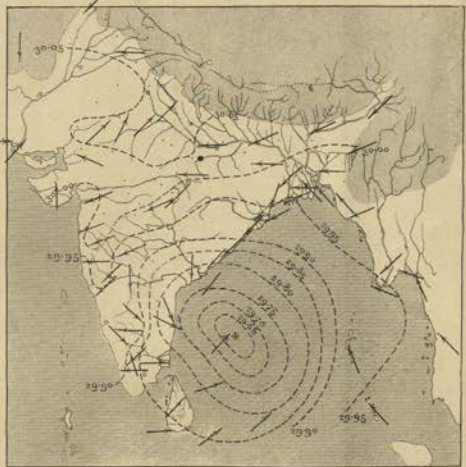
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7TH NOVEMBER 1886.

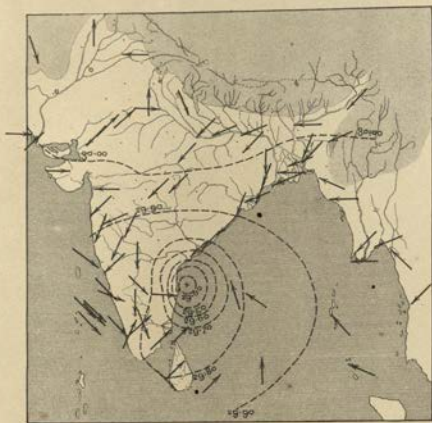


8TH NOVEMBER 1886.



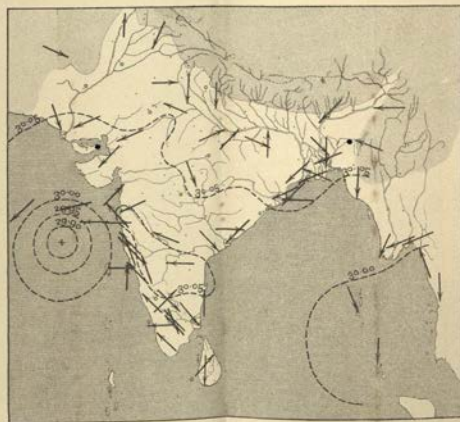
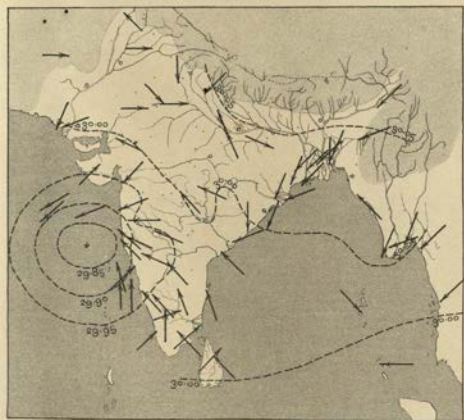
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10TH NOVEMBER 1886.

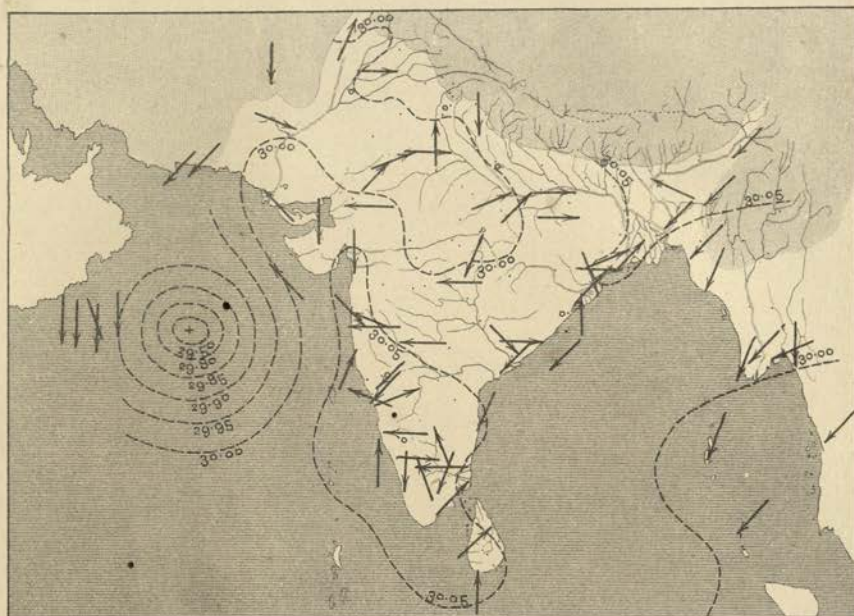


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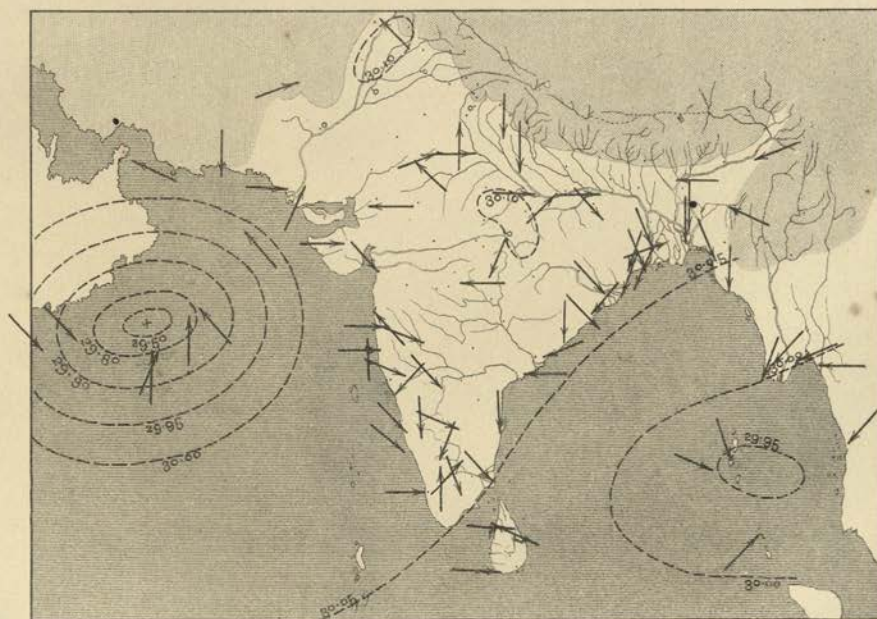
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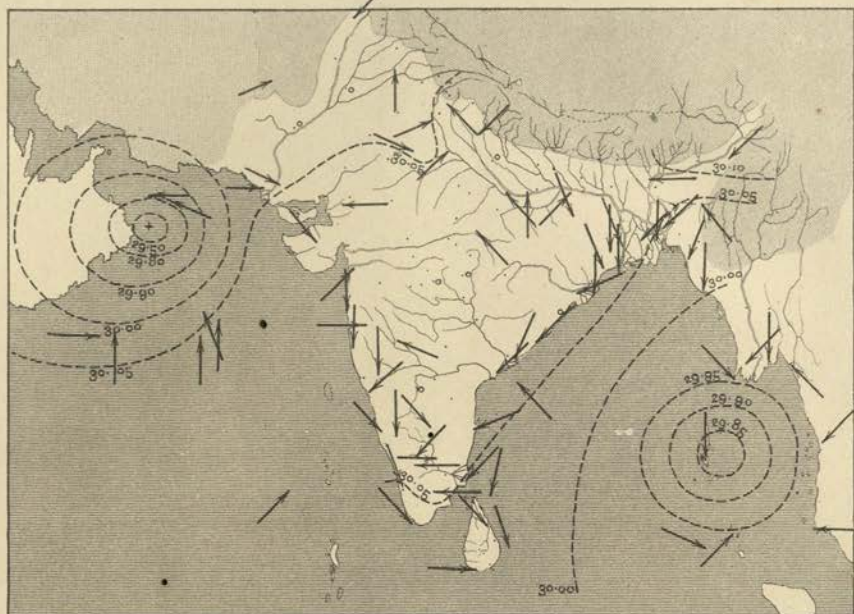
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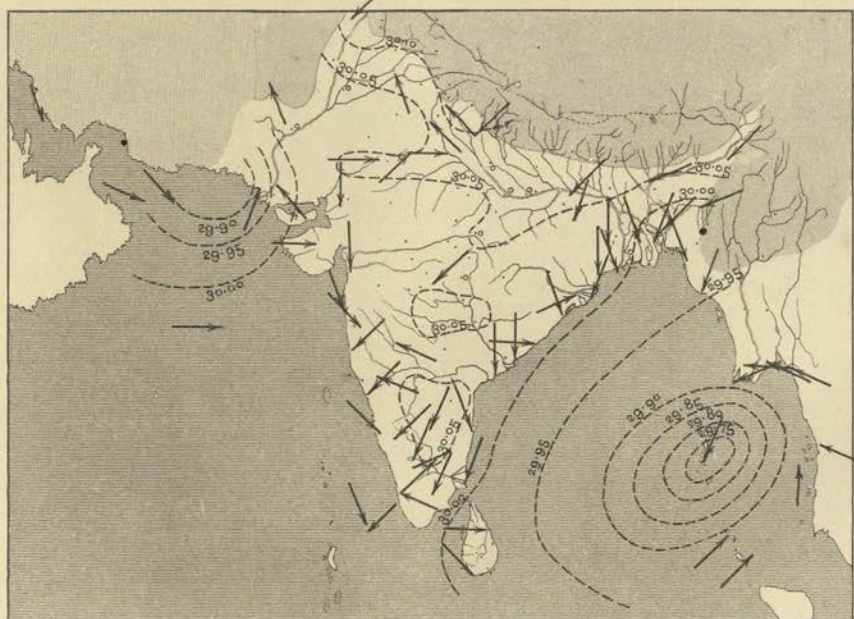
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15TH NOVEMBER 1886.



16TH NOVEMBER 1886.



17TH NOVEMBER 1886.



18TH NOVEMBER 1886.



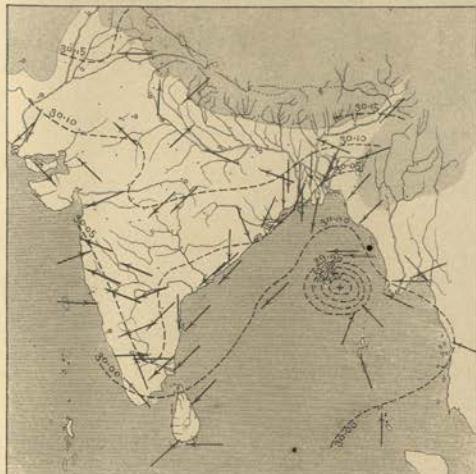
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20TH NOVEMBER 1886.



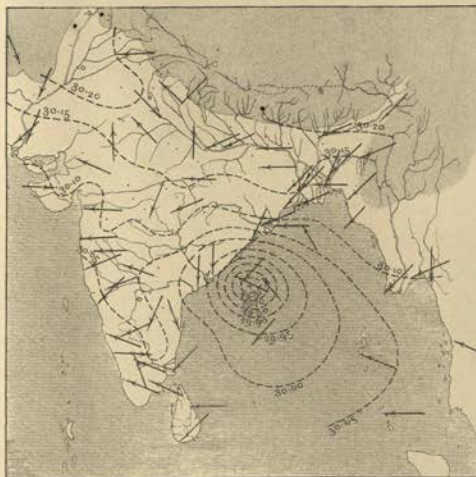
21ST NOVEMBER 1886.



22ND NOVEMBER 1886.



23RD NOVEMBER 1886.



24TH NOVEMBER 1886.



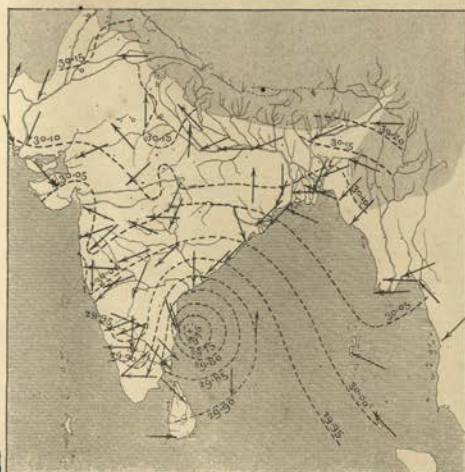
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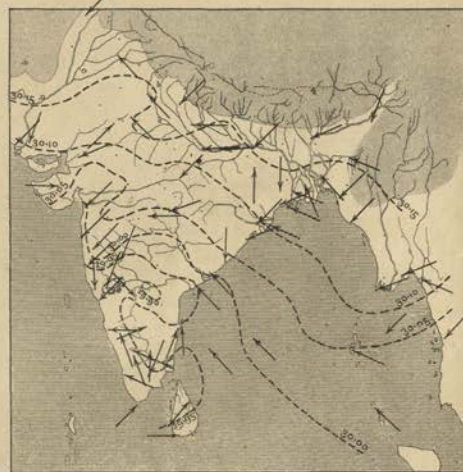
8TH DECEMBER 1886.



9TH DECEMBER 1886.



10TH DECEMBER 1886.



*VIII.—The Cyclone of the 25th May to the 2nd June 1881 in the Arabian Sea, by
FREDERICK CHAMBERS, Meteorological Reporter for Western India.*

RECEIVED ON THE 29TH DECEMBER 1887.

INTRODUCTION.

This paper gives an account of the violent cyclone which occurred in the Arabian Sea between the 25th of May and the 2nd of June 1881. The history of the storm is preceded, in the first chapter, by a brief general description of the meteorology of the Arabian Sea, and that part of the Indian Ocean which lies to the north of the Tropic of Capricorn. In this chapter it is shown that almost all the tropical cyclones of these seas originate in the equatorial belt of low atmospheric pressure. The general distribution of cyclones in these seas in different seasons of the year is worked out, but little is said on the theory of cyclone formation—a subject which has been very satisfactorily elucidated by Ferrel in his *Meteorological Researches*. The meteorology of the shores of the Arabian Sea in May 1881 is very briefly described and compared with the normal meteorological conditions of the month; but, unfortunately, it has not been possible to work out satisfactorily the special meteorological conditions which prevailed over the Arabian Sea before the commencement of the cyclone, the necessary information not having been obtainable.

In the second chapter the daily history of the storm is related. Before drawing the charts which illustrate this chapter, the barometric and thermometric observations were carefully corrected for index errors, which were in almost all cases determined by comparing the instruments used on board the ships indirectly with the standard instruments of the Colaba Observatory, Bombay. How very necessary this precaution to secure accuracy is, will be seen when it is pointed out that the errors of the barometers varied from about six-tenths of an inch below the truth to about two-tenths above it, and that in half the cases the errors exceeded one-tenth of an inch. The barometric observations were not only corrected for index errors, but also reduced to 32° Fahr. and to sea-level. They were next curved under each other for verification by intercomparison, and all erroneous observations thus brought to light were eliminated. They were then laid down on charts, and all glaringly inconsistent readings were rejected. In many cases the isobars are to a great extent conjectural, but they have always some evidence to rest upon, at least in some part of their course, and the rest has been filled in, where necessary, by assuming that their general form would approximate to that of a circle. The systematic and unexpected departures from symmetry which appear in the final results must therefore be inherent in the observations, and cannot be attributed

in any measure to bias of the mind while constructing the isobars, such bias, where existing, having been exerted rather on behalf of symmetry than against it. Before entering the barometric observations recorded at land stations on the charts, a correction for diurnal variation, to reduce them from 10 A.M. to noon, was applied to make them comparable with the noon observations recorded on the ships out at sea. The changes of pressure from day to day, on land, were so small that the proportionate change in two hours was negligible in all cases. The positions of the ships involved in the storm are frequently doubtful to a considerable extent, but in order to reduce the uncertainty as far as possible, the positions have in many cases been twice determined by dead reckoning, first, from the position last found by observation before entering the storm field, and secondly, by reckoning backwards from that first found by observation after leaving the storm field; and the mean of these two determinations has generally been adopted. In some cases, however, where the discrepancy between the two determinations by dead reckoning was great, and the intervals of time on which the two determinations depended differed much from each other, that determination which depended on the shortest interval of time was adopted. No attempt has been made to correct the wind observations for errors caused by motion of the ship. Such errors will tend to balance each other in the process of calculating average results.

In the third and last chapter the results are summarised and discussed, bringing to light the important fact that, at a constant distance from the centre of the cyclone, the incurvature of the winds on different sides varied in a systematic way from nothing to four points of the compass. This result proves that the usual rule for finding the bearing of the centre of a cyclone, *viz.*, six points to the left, when standing with the back to the wind, may be as much as two points in error one way or the other, and that consequently the rule requires very considerable modification. The systematic deviations from symmetry in the different octants of the cyclone have been traced to the influence which the south-westerly monsoon wind exerts upon the cyclone wind; and suitable modifications have been made in the rule for finding the bearing of the centre, so as to eliminate the error arising from this influence. The discovery of this relation between the south-westerly monsoon wind and the form of the cyclone appears to throw considerable light on the difficult subject of the bodily motion of cyclones, and from the conclusions arrived at in this chapter, the following inference has been drawn for use provisionally:—The direction of motion of cyclones in the Arabian Sea in May and June is about six points to the left of the direction towards which the normal monsoon wind blows.

CHAPTER I.

THE METEOROLOGY OF THE ARABIAN SEA AND THE ADJACENT PARTS OF THE INDIAN OCEAN.

The charts of meteorological information, published by the Hydrographic Department of the Admiralty in 1872, afford the best general view of the meteorological conditions of the Arabian Sea and Indian Ocean that is yet obtainable. These charts show the prevailing winds, the tracks of many well-authenticated storms, and the distribution of

barometric pressure and temperature in each quarter of the year. Recently, more detailed wind, pressure and current charts of the Bay of Bengal and adjacent parts of the Indian Ocean north of the equator, compiled by Mr. W. L. Dallas, have been published by the Meteorological Department of the Government of India, and similar charts of the Arabian Sea will shortly be issued. These charts show the prevailing winds and the pressure distribution in each month of the year. The Admiralty chart for the first quarter of the year shows that the north-east monsoon, or trade wind, extends over nearly the whole of the Arabian Sea, and as far south as the equator. Only along a narrow strip of sea near the west coast of India is the steady trade wind drawn out of its course, and converted into a north-west wind by the influence of the heated land. On nearing the equator the wind gradually changes into a north wind, and passing onward into the Southern Indian Ocean becomes at last a north-west wind, which prevails as far as 10° south latitude. Near the coast of Africa, the charts show an extension of north-easterly winds as far south as the middle of the Mozambique Channel; but far out in the sea, away from the coast, the winds to the south of the equator lose their tendency to blow from eastward, and, like those in the middle of the Indian Ocean, become first northerly, and afterwards north-westerly, and terminate about 10° S. The easterly direction near the African coast is therefore, in all probability, a deflection of the north-west trade wind caused by the heated land, just as in the case of the deflection from north-eastward to north-westward along the west coast of India. Over the greater part of the South Indian Ocean, from latitude 13° S to 27° S, and from Madagascar eastward, the south-east trade wind prevails, while the intermediate zone, between latitude 10° S and 13° S is a region of calms and conflicting north-west and south-east winds. It is, in fact, the meeting place of the north-westerly and south-easterly trades. A line drawn along the middle of this zone coincides with the position of the thermal equator, and with the middle of a belt of relatively low atmospheric pressure. On the chart for the first quarter, eight storm tracks are marked, all traversing the South Indian Ocean. All these storms appear to have originated in or near the belt of calms, and to have travelled at first in a south-westerly direction.

In the chart for the second quarter of the year (April, May and June) the south-east trade wind of the South Indian Ocean extends much farther northward than in the previous quarter, *viz.*, to about 4° S instead of to 13° S, the calm belt has moved northward to near the equator, and the north-east monsoon has given place to south-westerly winds in the western half of the Arabian Sea, and to variable north-westerly to south-westerly winds in the eastern half; the thermal equator has moved northward to the neighbourhood of the equator, and the high barometric pressure which characterised the Arabian Sea in the previous quarter has disappeared, and given place to relatively low pressure in the north. At the same time, the pressure has increased considerably over the area of the south-east trade winds to the south of the equator. The number of storm tracks in the South Indian Ocean has fallen from eight in the previous quarter to three in the second quarter of the year, while the number marked in the Bay of Bengal and the Arabian Sea has risen from none to seven, four in the former region, and three in the latter. The storms of the South Indian Ocean all travelled in a south-westerly direction, while six of those in the Bay of Bengal and Arabian Sea moved in a north-westerly direction, and one took a westerly course. The information contained in this chart is largely supplemented by that given in Mr. Dallas's Meteorological charts of the

Arabian Sea for the months of May and June, proof copies of which have been kindly placed at my disposal. The chart for May shows that near the equator, and along the western and northern shores of the Arabian Sea, the prevailing winds are south-westerly, while on the eastern shore they are westerly or north-westerly. In the middle of the sea, however, they are still northerly. Hence it may be inferred that there is an area of relatively low barometric pressure between the middle of the sea and the equator. The disposition of the isobaric lines supports this view, for although they show that the pressure is lowest in the extreme north and highest in the south-west near the equator, yet the relatively great distance between the isobars of 29.90 and 29.85 clearly indicates the existence of an area of relatively low pressure across the middle of the sea. The former line runs across the south-east corner of the chart, and the latter runs almost parallel to the Arabian and Indian coasts at an average distance from the coast of about 300 miles, leaving a space about 900 miles wide between the two lines, except near the African coast, where they approach much nearer. In the northern part of the Arabian Sea the isobaric lines for each five hundredth of an inch of mercury are, on the average, only 200 miles apart. The Meteorological chart of the Arabian Sea for the month of June shows a further fall of pressure in the north and north-east, and a further rise in the south-west, causing the broad band of nearly uniform pressure in the middle of the sea to disappear. It also shows that the south-west monsoon current is well established over the whole of the Arabian Sea, and southward to the equator.

The Admiralty chart for the third quarter of the year (July, August and September) shows that the south-east trade wind blows steadily over the whole of the South Indian Ocean from 25° S to the equator; that it there veers to south, and on passing the equator-veers still further, until it becomes the steady south-west monsoon current of the Arabian Sea. Near the west coast of India, to the southward of Bombay, it veers even to west and west-north-west. In the neighbourhood of the equator to the southward of the eastern half of the Arabian Sea, calms are of frequent occurrence. Indeed in the five degree square lying between latitudes 0° and 5° S, and longitudes 70° and 75° E, about one-third of the total number of observations of winds and calms are recorded as calms. It is difficult to understand the occurrence of these calms during the third quarter of the year, for, at this time, the thermal equator has moved far to the northward, where it stretches across Arabia, Beluchistan and Northern India; and the region of lowest pressure, towards which the winds must necessarily tend, is also far away in the north over the heated land. The equatorial tract is therefore no longer the meeting place of oppositely directed currents of air, which by neutralising each other might account for calms. The only apparent explanation is, that the prevailing winds show a tendency to rotate in a right-handed direction round this region, and if this tendency should at times be decidedly developed, it would create a very feeble cyclonic depression of the barometer with a calm centre, purely as an effect of the centrifugal force arising from the circulating winds. The isobaric chart shows no centre of low pressure in this region, but the lines are here wider apart than to the eastward or westward, thus suggesting the probability of the occasional, if not frequent, creation of a very slight depression. The isothermal chart for July shows that the thermal equator has been transferred from near the geographical equator to the northward of the Arabian Sea, and the isobaric chart for the quarter shows that the pressure has fallen in the north and risen in the neighbourhood of the equator.

No storm tracks are marked on the chart for the third quarter, but it is now known, chiefly from the reports of Mr. Eliot, that feeble cyclonic storms are of frequent occurrence in the north of the Bay of Bengal during the months of July, August and September, and that they usually travel across the Indian Peninsula in a west-north-west direction, and sometimes pass out into the Arabian Sea to the southward of Karachi.

The chart for the last quarter of the year (October, November and December) shows a very complete change in all the meteorological conditions of the Arabian Sea and the Indian Ocean. The change is so great that it has been necessary to mark the limits of the different winds for each month separately. In October the south-westerly winds have ceased to blow, and calms and variable light winds prevail over the whole of the Arabian Sea, and as far south as 5° N latitude. Between this latitude and the equator, however, south-westerly winds are still blowing, and over the whole of the area to the south of the equator, as far as about 27° S, the south-east trade prevails. In November, the north-east monsoon, or trade wind, has made its appearance over the northern part of the Arabian Sea as far south as 10° N latitude, and the northern limit of the south-east trade of the South Indian Ocean is marked on the chart as having retreated to about 7° S. In the intermediate area, *viz.*, that lying between 10° N, and 7° S, the winds appear to vary much, chiefly between north-west and south-west, with frequent calms. The wind chart of the Bay of Bengal for November shows that between the equator and 4° N latitude, the winds are usually from some westerly point; but a little farther northward, between 4° and 8° N latitude, they are very variable, coming from nearly all points of the compass, except from south. The most important point to be noticed is that a belt of variable winds and calms stretches across the south of the Bay along the parallel of 6° N latitude. In December the Admiralty chart shows that the south-east trade has retreated to about 12° S latitude, that the north-east monsoon or trade has advanced farther southward to about 4° N latitude on the eastern side of the Arabian Sea, and across the equator on the western side, extending farthest south along the coast of Africa, where it is traceable to about 10° S latitude. Between the equator and latitude 7° S, north-west winds prevail, leaving between them and the south-east trades a belt about 5° wide, where calms are of frequent occurrence. In October the thermal equator passes across the extreme north of the Arabian Sea, but in December it has retreated to about 10° S of the equator. It must, therefore, have travelled rapidly southward in the two intermediate months. Judging from observations made at Zanzibar during several recent years, and from the isobaric chart for the last quarter of the year, it appears that in the middle of the period, that is, in November, a band of relatively low atmospheric pressure stretches across the Indian Ocean in the neighbourhood of the equator. On the wind chart for the last quarter, eleven storm tracks are marked in the Indian Ocean and its arms, the Bay of Bengal and the Arabian Sea. Four of these originated near the equatorial calm belt in the South Indian Ocean and moved at first in the south-westerly direction, while six originated in the Bay of Bengal and moved in a north-westerly direction, and two passed across the Arabian Sea in the same direction.

The facts here very briefly described indicate, in a general way, the larger meteorological features of the Arabian Sea, and of the western half of that portion of the Indian Ocean which lies between the tropics, and they show the character of the atmospheric changes that take place over this area in the course of the year. Most of them are very

satisfactorily explained by the theory of the trade winds. This theory is useful, not only because it affords a rational account of the observed phenomena, but because it enables the mind to grasp the otherwise disconnected facts, and form them into a connected and an easily remembered whole. Briefly, the wind system of the Indian Ocean, like the wind system of the Atlantic and the Pacific Oceans, consists essentially of a north-easterly current to the north of the equator, and of a south-easterly current to the south of it, both flowing towards a relatively calm belt of maximum temperature and of minimum barometric pressure in the neighbourhood of the equator, where they rise and flow over in the upper regions of the atmosphere. The cause of the high temperature and low pressure in the equatorial regions is of course the heat of the sun, and if the sun were always to remain vertically over the equator, this wind system would remain throughout the year of the same character, but the annual motion of the sun, to and fro, through 47° of declination, gives rise to a corresponding bodily transfer of the calm belt from one hemisphere to the other, and this leads to corresponding modifications of the wind system. The bearing of the to-and-fro motion of this belt on the subject of cyclone formation is of very great importance, because there is reason to believe that nearly all the cyclones which occur within the tropics originate in the equatorial belt of calms, and, consequently, a knowledge of where this belt is situated at different times of the year carries with it a knowledge of the times when cyclones are most likely to be met with in different parts of the sea.

The reason why the currents of air on both sides of the thermal equator do not blow in a direct line towards it is that, in consequence of the rotation of the earth, bodies in motion on the earth's surface have a tendency to turn to the right in the northern hemisphere, and to the left in the southern hemisphere; and thus the current on the northern side of the equatorial calm belt, instead of blowing from north, turns to the right and becomes a north-east wind, while the current on the south side, instead of blowing from south, turns to the left and becomes a south-east wind. Hadley first pointed out the effect of the earth's rotation in deflecting north and south winds respectively into north-east and south-west winds in the northern hemisphere, and into north-west and south-east winds in the southern hemisphere; and for a long time it was supposed that the earth's rotation had no turning effect on east and west winds; but the comparatively recent mathematical investigations of Ferrel have shown that the deflecting force, due to the earth's rotation, affects winds from all directions in an equal degree, and that this force is twice as great as the earlier investigators had supposed. Its intensity varies as the sine of the latitude. It therefore vanishes at the equator, and is greatest at the poles. It turns the wind towards the right in the northern hemisphere, and towards the left in the southern, but it cannot of itself originate motion, and it is only called into action when motion has already been created by some other force. It acts always at right angles to the direction in which the wind is moving, but it does not, in any practical case, deflect it more than a right angle from the direction towards which the originating force impels it. This principle explains many peculiarities in the behaviour of the winds which were formerly supposed to militate against the truth of the theory of the trade winds; for instance, it explains why the winds of the western coast of India, in the hot weather months, March, April and May, blow from north-west instead of in a direct line from west towards the heated land, the westerly wind having been deflected to the right by the deviating force arising from the earth's

rotation. It also explains the well-ascertained fact that, in cyclones, the wind blows, not in a direct line towards the centre, in simple obedience to the originating force of the cyclone, but in some direction between the radius and the tangent to the circle drawn round the centre, on the right side of the radius, looking towards the centre, in the northern hemisphere, and on the left side in the southern, thus giving rise to the left-handed rotation of the wind (against the hands of a watch) round the centre of the cyclone in the northern hemisphere, and the right-handed rotation (with the watch hands) in the southern hemisphere. Like all true principles, it explains a multitude of other facts regarding the movements of the atmosphere, the sea, and solid bodies which would be inexplicable without it. It accounts for the fact that when in the Indian Ocean the thermal equator is to the south of the geographical equator, as it is in February, the trade wind on the north side of the thermal equator gradually changes its direction from north-east through north to north-west, the direction being north-east in the northern hemisphere, where the deflecting force is towards the right, north at the equator, where the deflecting force vanishes leaving the wind to go straight to the thermal equator, and north-west in the southern hemisphere, where the deflecting force acts towards the left. It also accounts for the similar change of direction of the trade wind on the south side of the thermal equator when the latter follows the sun into northern latitudes, as it does in the northern summer, for then the trade wind blows from south-east as far as the equator, veers to south on the equator, and to south-west to the north of the equator, in perfect accordance with the above-mentioned principle.

The mean position of the equatorial belt of high temperature and low atmospheric pressure in each month of the year is not yet known with very great accuracy. Some further light will doubtless be thrown on this important subject by the Meteorological charts of the Arabian sea, now passing through the press, but until similar charts of the south Indian Ocean are also prepared and published, our knowledge of this matter will necessarily be imperfect.

Meanwhile, much valuable information on this point may be gleaned from observations recorded at land stations on or near the shores of the Arabian Sea and Indian Ocean. With this object in view, the following table of average sea-level pressures for each month of the year has been compiled from the annual report on the Meteorology of India for the year 1885.

TABLE I.

STATION.	Latitude.	Longitude.	Number of years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
Aden . . .	12° 45' N	45° 3' E	4—6	30° 053	29° 998	29° 956	29° 878	29° 810	29° 709	29° 660	29° 678	29° 765	29° 917	29° 998	30° 044	29° 872
Bushire . . .	28° 59'	50° 49'	7—8	'126	30° 062	'080	'862	'745	'563	'469	'522	'696	'916	30° 045	'102	.841
Kurrachee . . .	24° 47'	67° 4'	11	'061	'018	'923	'825	'691	'562	'528	'613	'734	'900	'004	'069	'827
Bhuj . . .	23° 15'	69° 42'	11	'058	'006	'926	'816	'710	'586	'556	'636	'740	'890	29° 993	'052	'831
Rajkot . . .	22° 17'	70° 52'	11	'041	29° 991	'916	'820	'723	'605	'596	'667	'764	'895	'977	'028	'835
Surat . . .	21° 13'	72° 46'	11	'008	'972	'912	'826	'761	'658	'635	'697	'772	'877	'950	29° 996	'839
Bombay . . .	18° 54'	72° 49'	39	29° 979	'948	'901	'836	'792	'695	'693	'751	'808	'868	'936	'973	'848

STATION.	Latitude.	Longitude.	Number of years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
Ratnagiri . . .	17° 6' N	73° 23' E	11	29'976	29'945	29'904	29'832	29'793	29'741	29'749	29'785	29'832	29'867	29'905	29'949	29'856
Karwar . . .	14° 50'	74° 15'	8	'968	'945	'912	'848	'806	'785	'799	'814	'856	'869	'891	'938	'869
Mangalore . . .	12° 52'	74° 54'	8	'951	'937	'911	'865	'818	'819	'831	'845	'880	'878	'886	'927	'879
Cochin . . .	9° 58'	76° 17'	14-15	'929	'921	'904	'854	'837	'857	'873	'877	'898	'892	'901	'920	'889
Colombo. . .	6° 56'	79° 52'	16-17	'927	'925	'912	'865	'850	'864	'878	'880	'904	'902	'901	'915	'894
Galle . . .	6° 1'	80° 14'	15-17	'930	'924	'914	'867	'847	'867	'881	'882	'907	'905	'903	'914	'895
Zanzibar. . .	6° 10' S	39° 11'	7-9	'888	'889	'887	'915	'991	30'071	30'089	30'074	30'051	'998	'933	'908	'974
Mauritius . . .	20° 10' S	57° 29'	24-25	'946	'935	'980	30'013	30'084	'175	'212	'207	'195	30'136	30'064	30'002	30'079

From this table an estimate of the normal pressure at any time of the year, and in any part of the Arabian Sea, may readily be made by interpolation, and if the estimate is made with care, the result will seldom deviate more than two or three hundredths of an inch from the truth. The importance of being able to make such an estimate will be seen hereafter.

In compiling Table I, the following corrections have been applied—for Galle +·027, for Colombo +·014, for Ratnagiri +·009, for Surat +·003, for Rajkot +·009, and for Bhuj +·015. These corrections have been determined by plotting out the annual means on a form ruled to scale, the vertical scale being taken to represent the height of the barometer, and the horizontal scale the latitude. A smooth free-hand curve was then drawn through the points given by the observations of Cochin, Mangalore, Karwar, Bombay and Kurra- chee, all of which showed a regular progressive decrease of pressure from south to north, and the deviations of the points given by the observations of the remaining stations from this curve were regarded as constant errors of observation or of instrument. All the observations were first reduced to the Bombay standard barometer, which agrees with the Kew standard. The observations have also been reduced to what they would be if the force of gravity were constant in all latitudes, and had the value which it has in latitude 45°. The resulting values are given in Table II.

TABLE II.

STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
Aden . . .	29'977	29'922	29'880	29'802	29'734	29'633	29'584	29'602	29'689	29'841	29'922	29'968	29'796
Bushire . . .	30'081	30'017	'935	'817	'700	'518	'424	'477	'651	'871	30'000	30'057	'796
Kurrachee . . .	'006	29'963	'868	'770	'637	'507	'473	'558	'679	'845	29'949	'014	'772
Bhuj . . .	29'999	'947	'807	'737	'651	'527	'497	'577	'681	'831	'934	29'993	'772
Rajkot . . .	'980	'930	'855	'768	'662	'544	'535	'606	'703	'834	'916	'967	'774
Surat . . .	'945	'909	'849	'763	'698	'595	'572	'634	'709	'814	'887	'933	'776
Bombay . . .	'912	'881	'834	'769	'725	'628	'626	'684	'741	'801	'869	'906	'781

STATIONS.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
Ratnagiri . .	29'906	29'875	29'834	29'762	29'723	29'671	29'679	29'715	29'762	29'797	29'835	29'879	29'786
Karwar . .	'894	'871	'838	'774	'732	'711	'725	'740	'782	'795	'817	'864	'795
Mangalore . .	'875	'861	'835	'789	'742	'743	'755	'769	'804	'802	'810	'851	'803
Cochin . .	'849	'841	'824	'774	'757	'777	'793	'797	'813	'812	'821	'840	'809
Colombo . .	'845	'843	'830	'783	'768	'782	'796	'798	'822	'820	'819	'833	'812
Galle . .	'848	'842	'832	'785	'765	'785	'799	'800	'825	'823	'821	'832	'813
Zanzibar . .	'806	'807	'805	'833	'909	'989	30'007	'992	'969	'916	'851	'826	'892
Mauritius . .	'878	'858	'904	'942	30'015	30'102	'136	30'144	30'130	30'069	30'004	'933	30'010

The full significance of the pressures of Table II is best seen by plotting the values of each month on a form ruled to scale, taking the vertical scale to represent the barometric pressure, and the horizontal scale the latitude, and joining up corresponding points in the manner shown in Plate XXV. Each line of this diagram represents, for the month marked upon it, a barometric section of the atmosphere along a line passing through the respective stations¹. Each of the lines for the months October to March shows a well-marked trough-like depression with sloping sides. In October the bottom of the trough, or, in other words, the lowest pressure, is in Lat. 16° N; in November it is in Lat. 8° N; in December it is near the equator; in January it is in Lat. 6° S; and in February it has reached its farthest southerly limit, probably in Lat. 10° to 12° S. This gradual southerly transfer of the lowest pressure from Lat. 16° N in October, to about 10° S in February, is brought about by the gradual rising of the northern slope of the trough and the simultaneous gradual falling of the southern slope, the two changes producing what may be described as a bodily movement of the trough from north to south. In March the direction of motion is reversed and the trough begins to move northward, the southern slope beginning to rise and the northern slope to fall, bringing the lowest pressure again to about 6° S Lat. In April the bottom of the trough appears to be suddenly transferred to about Lat. 22° N, but there is reason to believe that this is due to the formation of an independent area of low pressure over the land as the summer advances, and that the equatorial trough of low pressure still exists in this month not far from the equator, although it is not clearly shown by the land observations. The Annual Reports on the Meteorology of India by Mr. H. F. Blanford clearly show that an independent area of low pressure forms over the land as early as February, and gradually deepens and moves northward as the season advances. The gradual deepening of this barometric depression over the land, and its northward movement, are clearly indicated by the barometric sections for May, June and July, and these show that at the same time the pressure gradually increases in the regions between the equator and 20° S Lat., thus causing the bottom of the southern barometric slope to move farther and farther northward. The effect on the equatorial trough of low pressure of the formation of the barometric depression over the land is gradually to bend down the upper part of the northern slope of the trough, until eventually, by the depression of the

¹ To avoid overcrowding, the pressure values of only nine stations out of the fifteen have been plotted on the diagram.

northern slope and the simultaneous elevation of the southern slope, the ridge of relatively high pressure which separates the land minimum from the equatorial depression entirely disappears, and then a single continuous barometric slope from south to north is established. The disappearance of this ridge probably takes place early in June, simultaneously with what is known in Western India as the "bursting of the monsoon." Its existence in May is clearly indicated on Mr. Dallas's Meteorological chart of the Arabian Sea for that month, and its complete disappearance in the following month is clearly proved by the chart for June. Barometric sections of these two charts taken along the meridian of 64° E are shown on Plate XXV. The corresponding barometric readings taken from the charts, and the corrections applied to them, are given in the following table :—

TABLE III.

	Latitude.	Normal pressure.	Gravity correction.	Pressure corrected to Lat. 45° .
		Inches.	Inch.	Inches.
May	$2^{\circ} 0' N$	29'900	—'084	29'816
"	$11^{\circ} 0' N$	29'850	—'079	29'771
"	$18^{\circ} 3' N$	29'850	—'068	29'782
"	$20^{\circ} 9' N$	29'800	—'063	29'737
"	$23^{\circ} 0' N$	29'750	—'059	29'691
June	$0^{\circ} 4' N$	29'900	—'085	29'815
"	$5^{\circ} 6' N$	29'900	—'082	29'818
"	$15^{\circ} 7' N$	29'850	—'073	29'777
"	$18^{\circ} 0' N$	29'800	—'069	29'731
"	$24^{\circ} 8' N$	29'562	—'055	29'507

The last reading is the pressure at Karachi, the chart for June being blank in the extreme north of the Arabian Sea.

From this table, and from Plate XXV, it appears that in May the equatorial minimum is in about Lat. $8^{\circ} N$, while the land minimum is far away in the north, the two being separated by a ridge of relatively high pressure in Lat. $15^{\circ} N$. In accordance with this distribution of pressure the chart for May shows that the prevailing winds are southerly near the equator, northerly in the middle of the Arabian Sea, and southerly in the north of the sea, while calms are frequent about Lat. $8^{\circ} N$, where the equatorial belt of low pressure is situated. In June the existence of the equatorial zone of low pressure, as an outstanding feature of the barometric distribution, is no longer traceable, although it is quite possible that by the adoption of a suitable method of eliminating from the observations the effects of the land depression the farther progress northward of the equatorial minimum might be traced without much difficulty. The Bombay Meteorological observations afford strong evidence that the equatorial zone of low pressure passes Bombay, going northward, about the middle of June,¹ and the barometric sections for June shew that the equatorial minimum has in this month coalesced with the land minimum ;

¹ Meteorology of the Bombay Presidency by C. Chambers, F. R. S., Arts. 31 and 113.

while the sections for July, August, and September show that the two minima remain combined throughout those months; but when, with the departure of summer, the land minimum fills up, as it does in October, the equatorial minimum again makes its appearance in latitude 16° N, and the same series of changes occurs year after year. It must not be supposed that these annual movements of the equatorial belt of minimum pressure take place with perfect smoothness. The small and irregular changes of pressure which are incessantly occurring would necessarily give rise to oscillatory movements of the belt about its mean position, and it is therefore far more probable that the onward movement is the result of a series of irregular advances and retirements, the southerly movements on the whole exceeding the northerly ones from October to February, and the northerly movements exceeding the southerly ones from February to May.

The barometric sections show that from October to May there is always, at the bottom of the equatorial trough of low pressure, a broad band, extending on the average over about 15° of latitude, within which the normal pressure is very nearly uniform, the extreme difference being not more than $\cdot 03$ of an inch. A fall of pressure of only $\cdot 03$ " on one side of the trough and a corresponding rise on the other would therefore be sufficient to throw the bottom of the trough seven or eight degrees to the north or south of its mean position, but a relatively much greater disturbance of the normal conditions than that here supposed would be required to carry the bottom of the trough much beyond these limits, because after passing them the normal pressure increases more rapidly, and a greater disturbance would be needed to counteract it.

One of the chief characteristics of the equatorial belt of low pressure is the nearly constant rainfall which takes place in it. In this respect it is very different from the region of low pressure which forms over the land in the summer, but which gives rise to little or no rain. By this characteristic it is possible to trace the continuous northerly movement of the belt beyond the place where the barometric features of the two areas coalesce. The following table of rainfall at a few selected stations exhibits this peculiarity in a striking manner. It shows not only the gradual northward progression of the band of heavy rainfall between February and July, but also its gradual return southward between July and February. Stations on the Deccan and Malwa plateaus have been selected, because there the rainfall is less likely than on the coast to be influenced by sudden change of elevation.

TABLE IV.—Average monthly and yearly rainfall in inches.

STATION.	Latitude.	Longitude.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
Lahore .	$31^{\circ} 34' N.$	$74^{\circ} 20' E.$	0.64	1.16	1.01	0.61	0.98	1.70	7.23	4.61	2.44	0.51	0.15	0.50	21.54
Neemuch .	$24^{\circ} 25' N.$	$75^{\circ} 0' E.$	0.10	0.16	0.12	0.09	0.54	3.69	11.54	10.29	5.76	0.86	0.03	0.25	33.43
Malegaon .	$20^{\circ} 34' N.$	$74^{\circ} 22' E.$	0.24	0.18	0.02	0.25	0.69	5.03	4.22	4.27	6.39	2.37	0.42	0.60	24.68
Mysore .	$12^{\circ} 18' N.$	$76^{\circ} 39' E.$	0.09	0.13	0.69	2.20	5.57	1.88	2.27	3.16	3.82	6.49	1.63	0.50	28.43
Galle .	$6^{\circ} 1' N.$	$80^{\circ} 14' E.$	4.29	3.41	4.83	8.70	11.06	8.31	5.36	5.37	7.61	13.07	11.67	6.28	89.96
Zanzibar .	$6^{\circ} 10' S.$	$39^{\circ} 11' E.$	2.32	4.17	4.88	12.68	8.26	1.19	2.20	1.92	1.33	3.35	6.31	6.41	55.02
Mauritius .	$20^{\circ} 10' S.$	$57^{\circ} 29' E.$	.89	12.89	8.10	4.81	4.05	2.78	3.43	4.90	4.00	2.07	2.36	7.39	63.67

From this table it appears that the rainy zone passes Latitude 20° N in June, that it advances at least as far North as 24° N in July, that it is nearly in the same position in August, and that in September it again passes Lat. 20° N on its retreat southward. It is probable therefore that its extreme excursion northward is at least as far as 24° N, and as the southerly limit of its movement is at least as far as 10° S, the full range of its oscillation in the course of the year is not less than 34° of latitude. There is no doubt that this oscillatory movement of the rainy zone has an important bearing on the frequency of occurrence of cyclones in different latitudes and different months of the year. The following table shows the number of cyclones recorded in each month of the year in the Bay of Bengal, the Arabian Sea, and the South Indian Ocean.

TABLE V.

	Number of years.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Total.
Bay of Bengal	139	2	0	2	9	21	10	3	4	6	31	18	9	115
Arabian Sea	234	4	3	2	9	13	20	2	2	3	4	10	2	74
South Indian Ocean.	40	9	13	10	8	4	0	0	0	1	1	4	3	53

No inference as to the relative frequency of storms in the different seas can be drawn from these numbers, because it is by no means certain that all the storms that have occurred have been recorded, and more may have passed unnoticed in one sea than in another. They show, however, the relative frequency in the different months of the year, and the data for the different seas may be made more comparable by calculating, as in the following table, how many storms occur in each month out of every hundred that occur in each sea.

TABLE VI.—*Relative Frequency of Cyclones in each Month.*

	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
Bay of Bengal	2	0	2	8	18	9	3	3	5	27	16	8
Arabian Sea	5	4	3	12	18	27	3	3	4	5	13	3
South Indian Ocean	17	25	19	16	8	0	0	0	2	2	8	6

Hence it appears that cyclones in the South Indian Ocean are most frequent in February, that is to say, in the month when the equatorial zone of low pressure is farthest south of the equator. From February onward the cyclone frequency in the South Indian Ocean decreases as the equatorial belt moves northward towards the equator, and when the belt passes the equator into northern latitudes the frequency of storms in the Arabian Sea and the Bay of Bengal gradually increases, the storms becoming more and more numerous as the belt moves farther and farther from the equator, and reaching a maxi-

imum of frequency in the Bay of Bengal in May and in the Arabian Sea in June, at which time storms have entirely disappeared from the South Indian Ocean. When, however, the equatorial belt of low pressure coalesces with the land depression, and passes to the extreme north of the Arabian Sea and Bay of Bengal, the cyclone frequency in these seas drops suddenly to a minimum; but when the land depression fills up, and the equatorial band of low pressure again makes its appearance in October in about Lat. 16° N, the frequency of storms suddenly increases to a maximum, and thereafter gradually declines to a second minimum in February or March, as the belt of low pressure moves southward. As the storms decrease in frequency to the north of the equator they increase in frequency to the south of it, and again reach a maximum in the South Indian Ocean in February. All these facts are in accordance with the hypothesis that tropical cyclones originate in the equatorial belt of low pressure, and are most frequent when the belt is farthest from the equator. Clearly, then, the atmospheric conditions which characterise this belt are those which favour the development of cyclones; but as the mechanical condition which determines the gyratory motion, *viz.*, the deflecting force arising from the earth's rotation, does not operate on the equator itself, and has a very small value near the equator, cyclones are not formed in the immediate neighbourhood of the equator; when, however, the belt of low pressure moves some distance north or south of the equator, where the deflecting force acquires a sensible value, cyclones begin to make their appearance, and to increase in frequency as the deflecting force increases with increase of latitude.

The chief meteorological features of the equatorial belt of low pressure are, 1st, relatively low atmospheric pressure compared with the pressure conditions on the northern and southern sides of it; 2nd, relatively high temperature; 3rd, frequency of calms and light winds of variable direction; 4th, an atmosphere saturated with moisture; and 5th, cloudy weather and frequent heavy rain.

In order to test the hypothesis that tropical cyclones originate in the equatorial belt of low pressure, the latitude of the place of origin of each of the storms of the Indian Ocean and its arms, the Arabian Sea and Bay of Bengal, whose tracks are marked on the Admiralty wind charts, has been read from the charts, and the average latitude for each month has been taken. It is assumed that the place of origin is sufficiently well indicated for this purpose by the commencement of the track. The results are shown below:—

TABLE VII.

		Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.
North latitude {	Number of storm.	0	0	0	4	2	0	0	0	0	3	2	2
	Mean latitude	—	—	—	$13^{\circ} 9$	$11^{\circ} 0$	—	—	—	—	$13^{\circ} 7$	$9^{\circ} 0$	$8^{\circ} 7$
South latitude {	Number of storms.	3	3	2	1	1	0	0	0	0	0	0	4
	Mean latitude	$14^{\circ} 0$	$15^{\circ} 7$	$15^{\circ} 3$	$12^{\circ} 8$	$11^{\circ} 3$	—	—	—	—	—	—	$10^{\circ} 4$

Few as these instances are, they clearly show that there is a progressive movement of the place of origin of storms similar to that which characterises the changes of the position of the equatorial belt of low pressure at different seasons of the year. For the

South Indian Ocean, the progressive change of the mean position of the place of origin is perfect, commencing at $10^{\circ}4$ S latitude in December and increasing to $15^{\circ}7$ S in February, and then gradually decreasing to $11^{\circ}3$ S in May. In the Arabian Sea and the Bay of Bengal the evidence afforded by the six storms of April and May is conflicting, those of April having originated farther north than those of May instead of farther south in accordance with the position of the equatorial belt of low pressure; but the storms of October to December show a regular southward movement of the mean place of origin from $13^{\circ}7$ N in October to $8^{\circ}7$ N in December, in accordance with the direction of movement of the belt at this time of the year. Further evidence on this point is afforded by Mr. Eliot's monthly track charts of the south-west monsoon storms generated in the Bay of Bengal during the years 1877 to 1881. The following results have been obtained by reading from these charts the latitude of the commencement of each storm track, and by taking the mean of all the readings in the same month.

TABLE VIII.

	May.	June.	July.	August.	September.	October.	November.	December.
Number of storms	4	6	5	12	9	6	6	1
Mean north latitude of place of origin .	$15^{\circ}5$	$19^{\circ}7$	$19^{\circ}8$	$20^{\circ}2$	$19^{\circ}4$	$16^{\circ}5$	$12^{\circ}7$	$10^{\circ}7$

These show that the mean latitude of the place of origin gradually increased from $15^{\circ}5$ N in May to $20^{\circ}2$ N in August, and thereafter gradually decreased to $12^{\circ}7$ N in November. The single storm of December appears to have been exceptional in that it originated farther north than is required by the hypothesis. It is clear, however, that the mean place of origin of these storms had a progressive movement from south to north from May to July or August, and from north to south from August to November in general agreement with the movement of the equatorial zone of low pressure. Mr. Eliot has pointed out that the position of storm tracks in the Bay of Bengal depends on the season of the year, that they are farther to the north in July than in May, and that they recede southwards from July to November.

It is a well observed fact that tropical cyclones almost invariably travel in such a direction as to increase their distance from the equator, moving usually in a north-westerly direction in the northern hemisphere, and in a south-westerly direction in the southern. If, then, these cyclones originate in the equatorial belt of low pressure, they will rarely, if ever, be met with on the equatorial side of this belt, nor on that slope of the trough of low pressure which extends into the opposite hemisphere. The distribution of cyclones in different latitudes and in different months shows that this is really the case, as will be seen from the following table in which the months are arranged horizontally and the latitudes vertically, and in which the latitude of the place of origin of each storm marked on the Admiralty Chart, and the month in which it occurred, are indicated by a cross (+) and the latitude of the beginning of each of Mr. Eliot's storm tracks and the month are indicated by a small circle.

TABLE IX.

		January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
North Latitude.	20	...	...	...	...	...	...	...	...	...	...	...	...
		...	...	...	...	...	...	...	...	...	...	...	...
	15	...	...	...	x	o	...	...	...	...	...	...	...
		...	...	...	...	...	...	...	...	...	...	...	...
	10	...	...	...	x	o	...	...	...	...	...	...	...
		...	...	...	...	...	...	...	...	...	...	...	...
	5	...	...	...	x	o	...	...	...	...	...	...	...
		...	...	...	...	...	...	...	...	...	...	...	...
	0	...	...	...	...	...	...	...	...	...	...	...	...
		...	...	...	...	...	...	...	...	...	...	...	...
	5	...	...	...	...	...	...	...	...	...	...	...	...
		...	...	...	...	...	...	...	...	...	...	...	...
South Latitude.	5	...	...	...	...	...	...	...	...	...	...	...	...
		...	...	...	...	...	...	...	...	...	...	...	...
	10	...	...	...	...	...	...	...	...	...	...	...	...
		...	...	...	...	...	...	...	...	...	...	...	...
	15	...	...	...	...	...	...	...	...	...	...	...	...
		...	...	...	...	...	...	...	...	...	...	...	...
	20	...	...	...	...	...	...	...	...	...	...	...	...
		...	...	...	...	...	...	...	...	...	...	...	...
	25	...	...	...	...	...	...	...	...	...	...	...	...
		...	...	...	...	...	...	...	...	...	...	...	...
	30	...	...	...	...	...	...	...	...	...	...	...	...
		...	...	...	...	...	...	...	...	...	...	...	...

In this table no storms are recorded as having originated in January, February, and March on the north side of the parallel of 11°S , that is, on the equatorial side of the belt of low pressure, which in these months lies to the south of the equator, nor on the northern slope of the trough of low pressure, which at this time covers the Arabian Sea and the Bay of Bengal. Conversely, no storms are recorded in this table as having originated in the months June, July, August, and September, between the equator and the parallel of 17°N , *i.e.*, on the equatorial side of the trough of low pressure, which at this time lies far to the north of the equator; nor are any recorded on the south side of the equator on the southern slope of the equatorial trough of low pressure, which in these months covers nearly the whole of the Arabian Sea, the Bay of Bengal, and the South Indian Ocean to about 25°S Lat. The absence of cyclones from these regions is therefore attributable,

1st, to the absence of the meteorological conditions which favour their development, that is, those conditions which obtain in the equatorial belt of low pressure; and 2nd, to that condition which causes cyclones, when once formed, to move away from the equator.

If the limits within which the equatorial trough of low pressure oscillates in each month could be definitely assigned, which unfortunately cannot at present be done, it would be possible to lay down with some precision the limits within which cyclones would probably be met with, and without which they would, in all probability, very rarely, if ever, occur. Meanwhile the above table furnishes some valuable information on this point, even as it stands, for it indicates the limits of latitude within which the cyclones of these seas are most likely to originate in each month of the year, and from within which they commence their north-westerly course in the northern hemisphere, and their south-westerly course in the southern.

In those months when the mean position of the equatorial belt of low pressure is very near the equator, *viz.*, in April and December, the temporary oscillations of the belt, arising from the ordinary small variations of pressure, will carry it first into one hemisphere and then into the other, and hence in these months cyclones may originate in both hemispheres, as shown by the table.

Theory of Cyclones.—In his important work on Cyclones, Waterspouts, and Tornadoes, Ferrel¹ has worked out very completely the theory of cyclones, beginning with the assumption that the atmosphere over some central area has a lower density than that over the external surrounding parts. Now the atmosphere in the equatorial zone of low pressure has a lower density than the air over the regions to the northward and southward of it. It therefore satisfies the fundamental assumption of Ferrel's theory with respect to density, but not with respect to form of the area, since the shape of the equatorial zone is not circular. What it is that occasionally converts the initial motion towards a medial line into motion towards a single centre situated on that line—the line running through the middle of the zone of low pressure—has yet to be discovered, but this appears to be the only point regarding the formation of tropical cyclones which still remains to be satisfactorily explained. Perhaps some light might be thrown on this question, if numerous accurate meteorological observations, made during the week before the commencement of a storm, could be obtained from all parts of the Arabian Sea, for such observations might possibly indicate the existence of a circular area of relatively low pressure overlying the place where the cyclone afterwards originates. Indeed it is by no means certain that the trough-like depression, which normally overlies the region where cyclones originate, does not, before the formation of a vortex, temporarily assume a circular form. Unfortunately the available meteorological information is too meagre and too uncertain to indicate clearly the actual meteorological conditions over the whole of the Arabian Sea before the formation of the cyclone of May and June 1881, and the observations recorded at land stations on the shores of the sea do not suffice for this purpose.

Meteorology of the shores of the Arabian Sea in May 1881.—The following table exhibits the mean values of the meteorological elements in May 1881 at several stations on the shores of the Arabian Sea, and compares them with the normal values of those elements:—

¹ "Meteorological Researches for the use of the Coast Pilot." Government Printing Office, Washington, 1880.

TABLE X.

STATIONS.	BAROMETRIC PRESSURE.			WIND.						TEMPERATURE.			RELATIVE HUMIDITY.			CLOUD.			RAIN.													
	Mean Pressure in May 1881.	Normal Pressure in month of May.	Abnormal Pressure in May 1881.	Mean Direction in May 1881.	Normal Direction in month of May.	Normal Percentage in month of May.	Abnormal Direction in May 1881.	Abnormal Percentage in May 1881.	Abnormal hourly velocity in May 1881.	Mean Temperature in May 1881.	Normal Temperature in month of May.	Abnormal Temperature in May 1881.	Mean Relative Humidity in May 1881.	Normal Relative Humidity in month of May.	Abnormal Relative Humidity in May 1881.	Mean amount in May 1881.	Normal amount in month of May.	Abnormal amount in May 1881.	Total Rainfall in May 1881.	Normal Rainfall in month of May.	Abnormal Rainfall in May 1881.											
	"	"	"	Miles.	"	"	"	"	Miles.	°	°	°	Per cent.	Per cent.	Per cent.	Scale 0 to 100 to 10	Scale 0 to 100 to 10	Scale 0 to 100 to 10	"	"	"											
Zanzibar . . .	29.965	29.968	-.003	S. 15° W.	80	7.1	S. 17° W.	69	7.5	1	2°	-0.4	78.3	78.4	-0.1	0	0	0	83	81	+2	0	0	0	826	+3.73	"	"	Normal Rainfall in month of May.	Abnormal Rainfall in May 1881.		
Aden . . .	704	715	-.011	S. 69° E.	55	12.3	S. 79° E.	44	12.6	+10°	+11	-0.3	85.6	84.9	+0.7	0	0	0	67	69	-2	...	...	...	11.96	-0.04	11.96	...	...	...	...	
Bushire . . .	706	719	-.013	N. 48° W.	73	8.2	N. 56° W.	65	8.9	+8°	+8	-0.7	82.4	80.8	+1.6	0	0	0	60	59	+1	...	...	...	...	...	...	...	...	...	...	
Karachi . . .	698	642	+0.06	S. 55° W.	85	15.9	S. 86° W.	80	17.7	-31°	+5	-1.8	84.6	85.1	-0.5	0	0	0	76	74	+2	0.77	2.23	-1.46	...	-1.46	...	0.05	-0.05	0.05	-0.05	
Bhuj . . .	314	305	+0.09	N. 88° W.	75	14.0	S. 88° W.	81	15.2	+4°	6	-1.2	88.7	86.6	+2.1	0	0	0	43	51	-8	0.29	1.26	-0.97	...	-0.97	...	0.17	0	0.17	...	...
Rajkot . . .	292	296	+0.02	N. 74° W.	61	14.8	N. 82° W.	78	14.9	+8°	-17	-0.1	87.9	87.9	...	0	0	0	...	44	...	1.24	1.55	-0.31	0.10	0.33	0.10	0.33	-0.23	0.33	-0.23	
Surat . . .	716	721	-.005	S. 54° W.	84	13.9	S. 55° W.	74	12.7	-1°	+10	+1.2	86.9	85.5	+1.4	0	0	0	59	59	0	0.40	1.57	-1.17	...	-1.17	...	0.23	-0.23	0.23	-0.23	
Bombay . . .	755	754	+0.01	S. 77° W.	58	12.6	N. 85° W.	74	10.2	-18°	-16	+2.4	85.1	84.9	+0.2	0	0	0	75	75	0	2.91	4.05	-1.14	0.36	0.53	0.36	0.53	-0.17	0.53	-0.17	
Ratnagiri . . .	673	673	0	S. 89° W.	57	...	N. 76° W.	67	...	-15°	-10	...	84.6	83.6	+1.0	0	0	0	67	69	-2	0.69	1.54	-0.85	0.53	0.53	0.53	1.36	-0.83	1.36	-0.83	
Karwar . . .	772	761	+0.11	W.	76	...	N. 76° W.	82	...	-20°	6	...	83.8	83.3	+0.5	0	0	0	74	74	0	4.23	3.06	+1.17	3.15	2.79	3.15	2.79	+0.36	2.79	+0.36	
Mangalore . . .	766	764	+0.02	S. 88° W.	70	4.1	N. 75° W.	76	4.3	-17°	6	-0.2	83.4	82.9	+0.5	0	0	0	74	74	0	5.18	4.44	+0.76	4.50	8.08	4.50	8.08	-3.53	8.08	-3.53	
Calcut . . .	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	
Cochin . . .	827	826	+0.01	N. 44° W.	55	2.1	S. 84° W.	52	2.2	+52°	+3	-0.1	82.2	82.0	+0.2	0	0	0	81	81	0	7.31	5.71	+1.60	11.66	12.58	11.66	12.58	-0.92	12.58	-0.92	
Colombo . . .	786	795	-.009	S. 42° W.	86	9.3	S. 54° W.	75	8.2	-12°	+11	+1.1	84.3	82.8	+1.5	0	0	0	74	79	-5	7.00	6.75	+0.25	6.38	12.08	6.38	12.08	-6.30	12.08	-6.30	
Galle . . .	780	779	+0.01	S. 86° W.	67	7.9	S. 86° W.	61	7.5	0	+6	+0.4	82.9	81.8	+1.1	0	0	0	88	87	+1	6.00	6.66	-0.66	4.88	11.06	4.88	11.06	-6.18	11.06	-6.18	

1 The positive sign (+) indicates that the mean direction of the wind was from the right of the normal direction; the negative sign (-) that it was from the left.

From this table it appears that on the shores of the Arabian Sea the mean barometric pressure in May 1881 differed very little from the normal pressure of the month. On the whole, there was a slight excess of pressure on the coast of India, and a slight defect on the African and Arabian coasts, and in the Persian Gulf. Along the west coast of India from Mangalore to Surat the prevailing winds were from a direction to the southward of the normal westerly directions. At other stations they differed irregularly from the normal directions. The percentages showing the prevalence or degree of steadiness of the prevailing winds indicate that along the coast from Mangalore to Bhuj the winds were not as steady as usual, but that at all other stations they were somewhat more so. At Surat and Bombay, and in Ceylon, the average velocity of the wind was greater than the normal, but at all other stations where the velocity was observed, it was less. The temperature appears to have been generally about 1° higher than the normal, and the relative humidity about normal. The actual quantity of moisture in the lower atmosphere was therefore appreciably greater than usual. But this does not appear to have been generally the case at high levels, for there was less cloud than usual at all the stations to the northward of Karwar, and at almost all, the rainfall was below the normal quantity. Only at Zanzibar was it considerably greater than usual.

CHAPTER II.

DAILY HISTORY OF THE STORM.

1881, May 25.—The following table gives the meteorological data for the 25th May 1881 at land stations round the coast of the Arabian Sea:—

TABLE XI.—10 A. M. 25th May 1881.

STATION.	Barometer.	Change in 24 hours.	Abnormal.	WIND.		Thermo- meter.	Relative Humidity.	Cloud.	Rainfall.	Remarks on the weather at 10 A. M.
				Direction.	Velocity mean of day. Miles per hour.					
	"	"	"			°	Per cent.	0 to 10	"	
Zanzibar . .	30.072	+0.016	+0.008	WSW	4	75.9	94	10	1.92	r.
Aden . .	29.789	+0.010	—0.046	SSE	8	91.9	62	...	...	
Bushire . .	.695	+0.023	—0.021	W	4	92.7	58	...	...	
Karachi . .	.723	+0.012	+0.022	SW	4	89.0	69	2	...	Strong wind.
Bhuj . .	.734	+0.011	+0.032	WNW	13	92.4	50	0	...	b.
Rajkot . .	.755	+0.012	+0.024	WNW	15	94.3	43	0	...	b.
Surat . .	.794	+0.016	+0.013	W	21	92.5	51	0	...	
Bombay . .	.828	+0.024	+0.011	NW	14	89.2	67	1	0.01	
Ratnagiri . .	.818	+0.046	+0.009	NW	...	90.1	59	0	...	
Karwar . .	.857	+0.056	+0.012	NW	...	85.0	76	8	0.01	Fresh Wind.
Mangalore . .	.853	+0.025	0	W	5	88.4	64	7	0.02	t.
Calicut . .	.851	—0.005	—0.028	NNW	7	84.6	78	5	0.07	d.
Cochin . .	.861	—0.045	—0.026	NNE	11	86.0	81	10	1.01	o.
Colombo . .	.858	+0.025	—0.030	SSW	13	81.0	78	8	...	Fine.
Galle . .	.860	+0.029	—0.018	SW	10	83.0	94	8	0.07	

The next tabular statement contains the meteorological information for the same date, collected from the ships which were at that time on the Arabian Sea, or on the North Indian Ocean between the coast of Africa and Long. 80° E.

TABLE XII.—25th May 1881.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. British Crown</i>	Noon	4° 5' N	58° 18' E	...	...	...	...	...
	2 P.M.	...	...	...	...	SW	...	Moderate breeze and cloudy weather.
<i>S.S. Clan Alpine</i>	1 A.M.	...	...	29° 792	86° 2	Variable	...	Light winds and cloudy weather.
	8 A.M.	...	...	...	...	NE	...	Light breeze and cloudy weather.
	Noon	15° 0' N	54° 16' E	...	...	...	...	Ditto ditto. Course N 75° E. Dis- tance 230 miles.
	1 P.M.	...	...	29° 792	86° 2	SE	...	At 2 P.M. light variable winds and showery.
	8 P.M.	...	...	...	...	SE	...	Steady breeze. Cloudy with passing showers.
	12 P.M.	...	...	...	...	SE	...	Ditto ditto.
<i>S. Cyromene</i>	1 A.M.	...	...	...	...	S	...	...
	4 A.M.	...	...	...	...	SSW	...	Moderate breeze and clear sky.
	Noon	15° 33' N	68° 10' E	29° 779	...	SSW	...	Light breeze and fine weather. Course N 37° E. Distance 115 miles.
	4 P.M.	...	...	...	...	SSW	...	Light breeze and fine weather.
	8 P.M.	...	...	...	...	SSW	...	Light breeze and clear sky.
	Mid- night.	...	...	...	...	SSW	...	Moderate breeze and cloudy weather.
<i>S. Deva Gangadur</i>	5 A.M.	...	...	...	...	E	...	Much thunder and lightning, with a squall of wind and rain from the eastward.
	Noon	14° 4' N	64° 15' E	29° 794	...	NNW	...	Course N 67° E. Distance 82 miles.
	2 P.M.	...	...	...	...	N	...	Light breeze with showers of rain.
	Mid- night.	...	...	...	...	Variable	...	Wind very unsettled in force and direction.
<i>S.S. Ellora</i>	4 A.M.	...	...	29° 869	84° 0	NNW	...	Light breeze. Sky cloudy.
	8 A.M.	...	...	29° 916	85° 0	...	...	Moderate breeze and fine weather.
	Noon	21° 59' N	68° 35' E	29° 906	85° 0	...	...	Course NW by ½ W. Dis- tance 179 miles.
	1 P.M.	...	...	...	...	W	...	...
	4 P.M.	...	...	29° 852	83° 0	W	...	Moderate breeze and fine weather.
	8 P.M.	...	...	29° 944	82° 0	W	...	Light breeze. Sky cloudy.
	Mid- night.	...	...	29° 896	85° 0	W	...	Ditto ditto.
<i>S. Exporter</i>	Noon	0° 22' N	59° 30' E	...	...	S	...	Light wind, clear weather with occasional passing squalls.
	1 P.M.	...	...	...	...	S	...	Light southerly wind and frequent rain squalls.
<i>S. Iris</i>	4 A.M.	...	...	...	...	S	...	Light breeze; hazy.
	Noon	0° 22' N	63° 51' E	...	...	ENE	...	Smart breeze, cloudy with passing showers. Course N 60° W. Dis- tance 127 miles.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. Iris</i> —contd.	2 P.M.	...	...	...	...	ENE	...	Moderate breeze, cloudy.
	4 P.M.	...	...	...	...	SSE	...	
	8 P.M.	...	...	...	...	S	...	
<i>S. Mistley Hall</i>	Mid- night.	...	...	...	...	S	...	Light breeze, hazy.
	1 A.M.	...	...	29.830	...	SW	...	Strong breeze and squally.
	8 A.M.	...	...	...	...	SW	...	Moderate breeze with pass- ing showers.
	Noon	6° 12' N	56° 44' E	...	...	SW	...	Ditto ditto. Course N 38° E. Distance 187 miles.
	1 P.M.	...	...	29.850	...	SW to W	...	
	4 P.M.	...	...	...	...	SW to W	...	Fresh breeze and squally.
	10 P.M.	...	...	...	...	SW	...	Moderate breeze and cloudy.
<i>S. Queen's Cliff</i>	10 A.M.	...	...	...	...	SW	...	Thunder and lightning to the westward. Sudden shift of wind from SE to SW, with heavy rain; overcast.
	Noon	6° 12' N	52° 51' E	...	...	...	...	Course N 23° E. Distance 117 miles.
	2 P.M.	...	...	...	...	S	...	Strong breeze and overcast sky.
	8 P.M.	...	...	...	...	SSE	...	Fresh breeze and cloudy.
	Mid- night.	...	...	...	...	SSE	...	Ditto ditto.
<i>S. Sleeve More</i>	6 A.M.	...	...	...	...	S	...	
	Noon	1° 20' N	62° 30' E	29.850	...	S	...	At 4 P.M. clear. At 8 P.M. light breeze and clear. Course N 25° W. Dis- tance 101 miles.
<i>S.S. Wheatfield</i>	1 A.M.	...	...	...	...	NW	...	Light breeze and fine weather; passed the Perim Light at 3.40 A.M.
	Noon	12° 15' N	44° 49' E	...	...			
	6 P.M.	...	...	...	...	ESE	...	
	12 P.M.	...	...	...	...	...	...	Light breeze and fine weather.

The distribution of barometric pressure and the character of the winds and weather are shown by the Chart for the day, Plate XXVI. The highest pressure is in the south-west corner, where the isobar of 29.9 runs in a south-easterly direction from near Magadoxo, on the coast of Africa, across to the equator in Long. 56° E; and the lowest pressure is in the extreme north, where the isobar of 29.7 runs across from east to west, passing near Karachi, giving a difference of only two-tenths of an inch from north to south on the western side of the Arabian Sea, and little more than one-tenth on the eastern side, from Karachi to Galle. The isobar of 29.8 runs across the middle of the Arabian Sea from Socotra to Karwar, bending southward in the eastern half, thus indicating the incipient formation of an area of abnormally low pressure about Lat. 14° N and Long. 67° E, where the barometer was about .07" below the normal height for the time of the year. On the east side, along the coast of India from Galle to Calicut, the pressure

was two or three hundredths of an inch below the normal, but farther north, between Karwar and Karachi, it was from '01" to '03" above it. On the west side, as far as can be inferred from the observations, it appears to have been slightly below the normal.

Near the equator, and between the African coast and Long. 64° E, the trade wind blew steadily from south, and more strongly near the coast than farther to the east. The *Iris* near the equator in Long. 64° E, had variable winds and passing showers in the day-time, and a steady light breeze from south during the night. Farther north, between Lats. 4° and 6° N the winds had already veered to south-west, from which direction they blew steadily with the force of a moderate breeze. Still farther north, in Lat. 14° N, the winds appear to have been light and variable. On the west coast of India they were north-westerly from Bhuj to Calicut, but in Ceylon they were south-westerly like the winds in the same latitude in the western half of the sea area. The *Hindustan*, in about Lat. 1° S and Long. 55° E had steady south-easterly breezes. There is no doubt therefore that on the 25th, before the formation of the cyclonic vortex, the south-east trade wind extended across the equator as far as about 8° N Lat., veering gradually from SE in southern latitudes to S on the equator, and to SW as it passed farther and farther northward.

Along the west coast of India, from Ratnagiri to Karachi, fine clear weather prevailed, but from Karwar to Galle the skies were cloudy or overcast, and an inch of rain had fallen at Cochin during the previous twenty-four hours. In the central part of the sea area the weather appears to have been clear and fine, but in the western part cloudy rainy weather prevailed along a broad band running in a north-easterly direction from Zanzibar to Lat. 14° N, Long. 64° E. In the northern portion of this band there was much thunder and lightning.

1881, May 26.—The meteorological data for the 26th May are contained in the following tabular statements:—

TABLE XIII.—10 A.M., 26th May 1881.

STATION.	Barometer.	Change in 24 hours.	Abnormal.	Wind.		Thermometer.	Relative Humidity.	Cloud.	Rainfall.	Remarks on the weather at 10 A.M.
				Direction.	Velocity mean of day.					
					Miles per hour.	°	Per cent.	0 to 10		
Zanzibar . . .	30"081	+ "009	+ "014	SW	3	78.8	82	4	...	
Aden . . .	29.822	+ "033	— "010	Calm	7	91.1	68	...	...	
Bushire . . .	'681	— "014	— "029	NE	8	99.7	39	...	...	
Karachi . . .	'734	+ "014	+ "037	SW	18	89.0	66	0	...	Strong wind.
Bhuj . . .	'751	+ "017	+ "049	WNW	13	93.2	46	0	...	
Rajkot . . .	'762	+ "007	+ "034	W	13	94.1	42	0	...	
Surat . . .	'859	+ "065	+ "081	W	14	93.5	46	0	...	
Bombay . . .	'844	+ "016	+ "029	WNW	10	89.0	64	5	...	Slight sea.
Ratnagiri . . .	'815	+ "003	+ "008	NW	...	91.1	55	0	...	
Karwar . . .	'859	+ "002	+ "015	W	...	88.0	64	4	...	Moderate wind
Mangalore . . .	'869	+ "016	+ "016	NE	4	84.9	79	10	0.09	
Calicut . . .	'880	+ "029	+ "000	Calm	8	82.6	78	5	0.34	d. r.
Cochin . . .	'895	+ "034	+ "007	N	1	83.5	85	10	3.06	o. r.
Colombo . . .	'882	+ "024	— "006	WSW	11	85.5	74	9	...	f.
Galle . . .	'877	+ "017	— "001	NW	10	84.0	87	8	0.01	Strong wind.

TABLE XIV.—26th May 1881.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. Berengaria</i>	Noon	16° 23' N	66° 11' E	29.750	...	NE	...	Light breeze backing from ENE to NE; fine weather. Very heavy increasing sea from SE; course N 54° E. Distance 49 miles.
	1 P.M.	...	...	...	...	...	...	Moderate breeze and clear.
	10 P.M.	...	...	...	...	...	...	Squally.
<i>S. Braidwood</i>	10 A.M.	...	...	...	...	E	...	
	Noon	0° 15' N	55° 10' E	...	...	...	...	
	2 P.M.	...	...	...	...	SE	...	Moderate breeze. Overcast and threatening squalls.
<i>S. British Crown</i>	Midnight	...	...	...	...	SSE	...	Fine breeze with slight showers.
	Noon	6° 12' N	59° 50' E	...	...	...	...	
	1 P.M.	...	...	...	...	SW to W	...	Moderate breeze and cloudy weather.
	10 P.M.	...	...	...	...	...	...	Overcast sky.
<i>S. Choice</i>	Midnight	...	...	...	...	SW ½ S	...	Squally, with lightning. Shipping a great deal of water on deck.
	Noon	0° 1' N	53° 6' E	...	...	...	...	
	1 P.M.	...	...	...	...	SSE	...	Strong breeze and fine weather.
<i>S.S. Clan Alpine</i>	1 A.M.	...	...	29.792	85.8	NE	...	Light winds. Lightning to the SE.
	4 A.M.	...	...	...	...	Variable	...	Cloudy.
	8 A.M.	...	...	...	...	SE	...	Light winds. Gloomy weather.
	Noon	15° 51' N	57° 59' E	...	...	SE	...	Ditto ditto.
	1 P.M.	...	...	29.792	87.2	SE	...	Course N 76° E. Distance 223 miles.
	4 P.M.	...	...	...	...	SE	...	
	9 P.M.	...	...	...	...	SSE	...	Steady breeze and fine clear weather.
<i>SS. Clandon</i>	Midnight	...	...	...	...	SSE	...	Light breeze and cloudy weather.
	3 P.M.	Near	Aden	...	...	Calm	...	Ditto ditto.
	10 P.M.	...	...	...	...	WSW	...	Light variable winds and hot.
<i>S. Cypromene</i>	4 A.M.	...	...	...	...	SSW	...	Ditto ditto.
	Noon	14° 35' N	69° 30' E	29.819	...	SSW	...	Moderate breeze and cloudy weather.
	1 P.M.	...	...	...	...	S	...	Moderate breeze and passing showers. Course N 51° E. Distance 98 miles. Fine clear weather.
	8 P.M.	...	...	...	...	S	...	
	Midnight	...	...	...	...	S	...	Fine clear weather; heavy swell from SW.
		...	...	...	...		...	Fine breeze and cloudy weather. Heavy swell from SW.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. Deva Gangadur</i>	2 A.M.	...	...	...	...	...	...	Wind increasing.
	8 A.M.	...	...	...	...	...	...	Heavy cross sea.
	Noon	13° 58' N	65° 48' E	29° 695	...	...	...	Moderate gale with heavy showers. Course S 84° E. Distance 91 miles.
	2 P.M.	...	...	...	...	NW	...	Gale increasing. Ship rolling heavily and taking large quantities of water on deck.
<i>S.S. El'ora</i>	Mid- night.	...	...	...	...	...	...	Gale increasing with heavy rain squalls.
	4 A.M.	...	...	29° 932	83° 0	W	...	
	8 A.M.	...	...	29° 968	84° 0	W	...	
	Noon	24° 39' N	66° 56' E	29° 961	83° 0	W	...	
<i>S.S. Eschol</i>	1 P.M.	...	...	...	...	Variable	...	Light variable airs with hot sultry weather.
	Mid- night.	...	...	...	...	SW	...	Ditto ditto.
<i>S. Exporter</i>	5 A.M.	...	...	...	...	W	...	Wind changed to west, blowing fresh.
	7 A.M.	...	...	...	...	NW	...	Wind moderate.
	Noon	2° 33' N	59° 34' E	...	...	...	...	
	1 P.M.	...	...	...	...	S	...	
<i>S. Hindustan</i>	4 A.M.	...	...	...	...	SE by S	...	Wind very steady.
	8 A.M.	...	...	...	...	...	...	Fresh breeze and clear weather.
	Noon	1° 7' N	54° 23' E	...	...	...	...	Steady breeze and clear weather. Course N 39° E. Distance 159 miles.
	1 P.M.	...	...	...	...	SE by S	...	Fine clear weather.
	4 P.M.	...	...	...	...	SE by S	...	Very steady breeze and clear weather.
	8 P.M.	...	...	...	...	SE by S	...	Ditto ditto.
	Mid- night.	...	...	...	...	SE by S	...	Steady breeze and clear weather.
	2 A.M.	...	...	...	...	S	...	Light breeze, hazy, passing showers.
<i>S. Mistley Hall</i>	Noon	1° 54' N	63° 47' E	29 877	...	...	...	Course N 30° W. distance 92 miles.
	2 P.M.	...	...	...	...	S	...	Light breeze. Showers of rain.
	1 A.M.	...	...	29° 850	...	SW by S	...	Fresh breeze and cloudy weather. Ship rolling, and straining heavily.
	Noon	8° 12' N	59° 18' E	...	...	...	...	Ditto ditto. Course N 41° E. Distance 182 miles.
<i>S. Queen's Cliff</i>	1 P.M.	...	...	29° 830	...	SW	...	Upper main topsail carried away at 3 P.M.
	4 A.M.	...	...	...	...	S	...	
	Noon	2° 19' N	54° 44' E	...	...	S	...	Light breeze and clear sky.
	2 P.M.	...	...	...	...	SSW	...	Course N 34° E. distance 158 miles.
	Mid- night.	...	...	...	...	...	...	Light breeze and clear sky. Fresh breeze, squally.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. Slieve More</i>	1 A.M.	...	...	"	0	SE	...	Light breeze and clear weather.
	8 A.M.	...	...	...	...	SE	...	Increasing breeze and clear weather.
	Noon	2° 52' N	61° 41' E	29'900	...	S	...	Brisk breeze and cloudy weather. Course N 28° W. Distance 104 miles.
	1 P.M.	...	...	...	...	SSW	...	
	8 P.M.	...	...	...	...	SSW	...	Light breeze and clear weather.
<i>S.S. Tebe</i>	Noon	12° 30' N	44° 25' E	29'733 ^p	...	NW	2	
<i>S.S. Tenasserim</i>	4 A.M.	Karachi to Karachi.		29'779	82'7	SW	3	b. c. Slight westerly swell.
	8 A.M.	...	...	29'893	84'7	Variable	1	b. c. v. Fine weather. Smooth sea.
	Noon	16° 9' N	72° 46' E	29'841	85'7	SW	1	b. c. SW swell. Fine weather. Course S 35° E. Distance 216 miles.
	4 P.M.	...	...	29'848	86'7	SW	2	b. v.
	8 P.M.	...	...	29'821	85'7	SWbyW	2	b. c. l. Fine weather and smooth sea.
<i>S.S. Wheatfield</i>	Mid-night.	...	...	29'821	85'7	SW	1	b. c. Light SW swell.
	1 A.M.	...	...	...	...	ESE	...	Light breeze and fine weather.
	7 A.M.	...	...	...	...	Calm	...	
	Noon	13° 9' N	47° 44' E	...	...	...	...	
	5 P.M.	...	...	...	...	SW	...	Light breeze and fine weather.
	8 P.M.	...	...	...	...	Variable	...	Ditto ditto.

The chart for the day, Plate XXVII, shows that the general distribution of pressure round the shores of the Arabian Sea and near the equator was nearly the same as on the 25th, the only change having been a slight and nearly uniform rise. In the middle of the Arabian Sea, however, the pressure had fallen about a tenth of an inch, forming a slight but distinct centre of low pressure about Lat. 13° 40' N, and Long. 66° 54' E where the barometer had gone down to a little below 29'7 inches. The normal or average pressure for the 26th May, in this position, is about 29'85. The actual pressure at noon on that date was therefore only a little more than .15 below the normal, and yet this small depression was sufficient to give rise to decided cyclonic indications. The *S. Deva Gangadur*, about 50 miles from the centre, and on the west side of it, had a moderate gale from NW, with heavy showers of rain. Both wind and rain increased as the day advanced, and the barometer fell rapidly. The *S. Berengaria*, about 200 miles to the north-north-west of the centre, had a light breeze from N E, and a very heavy increasing sea from SE, which was doubtless produced by the strong SE wind on the east side of the centre. The *S. Cypromene*, about 200 miles to the east-north-east of the centre, had a moderate breeze from SSW and S, and a heavy swell from SW, with cloudy weather and passing showers. It should be noticed that both the last-mentioned vessels reported the swell to be from a direction several points to the right of that from which the wind blew. In the south of the area the wind system had moved bodily northward, the wind now being from SE on the equator, from due south on the parallel of Lat. 2°

N, and from SW between Lat. 6° and 8° N. It had at the same time increased in strength and was now blowing with an average force of 4·4 of Beaufort's scale, that is, between a moderate and a gentle breeze. On the previous day the average force was 3·7. On the west coast of India the winds were light and chiefly north-westerly. In Ceylon they were light and westerly. In the south-west of the sea area the weather had cleared considerably since the 25th, but had become more cloudy and rainy in the neighbourhood of the barometric depression and on the Malabar Coast.

1881, May 27.—The meteorological information for the 27th May is contained in the two following tables, and much of it is graphically represented on the chart for the day, Plate XXVIII.

TABLE XV.—10 A.M., 27th May 1881.

STATION.	Barometer.	Change in 24 hours.	Abnormal.	WIND.		Thermometer.	Relative Humidity.	Cloud.	Rainfall.	Remarks on the weather at 10 A.M.
				Direction.	Velocity mean of day.					
					Miles per hour.	°	Per cent.	0 to 10.	"	
Zanzibar . .	30·079	—·002	+·009	SW	4	77·5	87	7	0·03	
Aden . .	29·777	—·045	—·052	SSE	7	89·6	65	...	...	
Bushire . .	·679	—·002	—·025	N	9	97·7	38	...	...	
Karachi . .	·721	—·016	+·028	SW	17	89·0	73	1	...	
Bhuj . .	·726	—·025	+·031	WSW	13	92·2	50	0	...	
Rajkot . .	·757	—·005	+·033	W	15	90·3	47	0	...	
Surat . .	·795	—·064	+·020	W	15	90·5	60	0	...	
Bombay . .	·840	—·004	+·028	SW	8	87·9	61	2	...	
Ratnagiri . .	·816	+·004	+·013	S	...	89·6	58	1	...	
Karwar . .	·841	—·018	+·002	SW	...	85·1	76	6	0·07	Fresh wind.
Mangalore . .	·893	+·024	+·040	E	4	78·0	91	10	0·34	
Calicut . .	·893	+·013	+·013	N	9	79·6	86	6	0·58	d. r.
Cochin . .	·891	—·004	+·002	NNW	2	85·0	74	6	0·50	
Colombo . .	·849	—·033	—·039	WSW	14	87·5	69	2	...	
Galle . .	·847	—·030	—·031	NW	11	84·0	87	3	0·61	Strong wind.

TABLE XVI.—27th May 1881.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermometer.	WIND.		REMARKS.
						Direction.	Wind.	
S. Africa . .	Noon	16° 2' N	66° 55' E	29·809 ⁹	...	NE	...	Fresh increasing breeze and cloudy weather. Barometer falling. Course SE by E.
	6 P.M.	...	...	29·799 ⁹	...	NNE	...	Increasing breeze, squalls and rain. Lightning in E and ESE horizon.
	Mid-night.	...	...	29·789 ⁹	...	...	...	

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. Berengaria</i>	5 A.M.	...	...	...	...	...	...	Squalls increasing.
	Noon	15° 22' N	67° 19' E	29° 650	...	...	...	Moderate increasing gale. Sea more from Eastward Course S 49° E. Distance 89 miles.
	1 P.M.	...	...	...	...	ENE	...	Heavy squalls and rain.
	10 P.M.	...	...	...	...	NNW	...	
<i>S. S. Bessie Morris</i>	1 A.M.	...	...	29° 517	84° 5	ENE	2	Light breeze and dark cloudy weather. Light- ning to the E and SE.
	6 A.M.	...	...	29° 621	...	NW	...	
	8 A.M.	...	...	...	...	W	...	Squally with rain and thun- der and lightning.
	Noon	13° 51' N	52° 46' E	29° 726	80° 5	NNW	...	High confused sea. Course N 82° E. Distance 216 miles.
	4 P.M.	...	...	...	...	NNE	...	
	8 P.M.	...	...	...	...	SE	2	
	Mid- night.	...	...	...	...	SSW	...	Fresh breeze and fine wea- ther.
	2 A.M.	...	...	...	...	SSE	...	Squalls and heavy showers.
<i>S. Braidwood</i>	10 A.M.	...	...	...	...	S	...	Do. do.
	Noon	2° 23' N	55° 40' E	...	...	...	...	Do. do.
	2 P.M.	...	...	...	...	SE	...	Moderate breeze and heavy squall. Wind hauled to the SW with thunder and lightning.
	Mid- night.	...	...	...	...	...	...	Moderate breeze and squally.
<i>S. British Crown</i>	Noon	7° 40' N	61° 15' E	...	...	SW ½ S	...	Squalls at 11 A.M.
	2 P.M.	...	...	...	...	SW by S	...	Fresh breeze, cloudy and gloomy.
	Mid- night.	...	...	...	...	...	...	Overcast sky.
<i>S. Choice</i>	2 A.M.	...	...	...	...	SSE	...	
	Noon.	2° 15' N	55° 2' E	29° 905	...	SSE	...	Course N 32° E. Distance 159 miles.
	1 P.M.	...	...	...	...	SE	...	Strong breeze and cloudy weather
	3 P.M.	...	...	...	...	...	...	Squally.
<i>S.S. Clan Alpine</i>	8 P.M.	...	...	...	...	SW	...	Strong breeze and showery weather.
	9 P.M.	...	...	...	...	SW	...	Fresh breeze and overcast sky.
	1 A.M.	...	...	29° 792	88° 2	SW	...	Light wind and cloudy weather. Heavy SW swell.
	8 A.M.	...	...	...	...	SSE	...	Light airs and fine clear weather.
	10 A.M.	...	...	...	...	Calm	...	
	Noon	16° 44' N	61° 58' E	...	...	...	...	Fine clear weather. Course N 76° E.; distance 240 miles.
	1 P.M.	...	...	29° 672	83° 8	NW	...	
	4 P.M.	...	...	...	...	NW	...	Light breeze and clear weather.
	8 P.M.	...	...	...	...	...	...	Moderate breeze and cloudy weather.
	Mid- night	...	...	29° 512	...	NNW	...	Moderate breeze and over- cast sky.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S.S. Clandon</i>	1 A.M.	...	...	...	...	SW	...	Light breeze and clear weather.
	9 A.M.	...	...	...	...	WSW	...	Ditto ditto.
	Noon	13° 0' N	48° 25' E	...	...	WSW	...	Ditto ditto.
	5 P.M.	...	...	...	...	Var.	...	
	8 P.M.	...	...	...	...	...	...	Fresh breeze and cloudy weather.
	Mid- night.	...	...	...	...	Var.	...	Light airs.
<i>S. Cypromene</i>	4 A.M.	...	...	...	...	S	...	Moderate breeze and passing showers.
	Noon	15° 57' N	70° 41' E	...	...	S	...	Pleasant breeze and fine weather; course N 39° E. Distance 106 miles.
	2 P.M.	...	...	...	...	...	...	Squally with heavy rain.
	Mid- night.	...	...	...	...	...	...	Pleasant breeze and fine weather.
<i>S. Deva Gangadur</i>	2 A.M.	...	...	...	...	...	...	In a violent squall, the lower maintop sail blew away.
	10 A.M.	...	...	...	...	...	...	Heavy sea breaking over the vessel, washing away bulwarks and bursting open the cabin doors, filling cabin full of water.
	Noon	13° 45' N	66° 15' E	29.496	...	...	...	Course N 67° E. Distance 36 miles.
	2 P.M.	...	...	...	...	NW	...	Blowing a gale with heavy squalls of wind and rain.
	4 P.M.	...	...	...	...	Var.	...	
	6 P.M.	...	...	...	...	...	...	Bent storm try-sail; unable to bend another on account of the violence of the squalls.
<i>S.S. Ellora</i>	8 A.M.	...	...	29.938	84.0	...	...	Moderate breeze and fine weather.
	Noon	23° 43' N	66° 59' E	30.043	82.0	...	...	Ditto ditto westerly swell; course S 67° E. distance 65 miles.
	4 P.M.	...	...	29.936	85.0	SW	...	Moderate breeze and fine weather.
	8 P.M.	...	...	30.078	84.0	SW	...	Light breeze and fine weather.
<i>S.S. Eschol</i>	8 A.M.	...	...	...	...	SW	...	
	Noon	13° 12' N	47° 49' E	...	...	...	...	Moderate breeze.
	2 P.M.	...	...	...	...	SW	...	Moderate breeze with hot weather.
	Mid- night.	...	...	...	...	Var.	...	Lightning and light breeze.
<i>S. Exporter</i>	1 A.M.	...	...	...	...	S	...	
	Noon	4° 9' N	60° 12' E	...	...	S	...	Light southerly wind and cloudy weather.
<i>S. Hindustan</i>	8 A.M.	...	...	...	...	SSE	...	
	Noon	3° 2' N	56° 11' E	...	...	...	...	Very steady breeze and clear weather; course N 43° E. Distance 45 1/2 miles.
	1 P.M.	...	...	...	...	SSE	...	Fresh breeze and fine weather.
	4 P.M.	...	...	...	...	...	...	Steady breeze and fine weather.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>Hindustan</i> —contd.	8 P.M.	...	...	...	...	...	...	Commences to look squally in SW. Lightning round to the westward.
<i>S.S. Inchulva</i>	Mid-night.	...	...	...	...	S	...	Looking squally in the westward.
	1 A.M.	...	...	...	...	SE to S	...	Fine weather, clear sky; swell from S E.
	5 A.M.	...	...	...	...	...	...	Light airs.
	Noon	...	...	...	...	W	...	Moderate wind; heavy SW swell, course N 60° E. Distance 210 miles.
	4 P.M. to 8 P.M.	...	...	...	...	...	...	Sky overcast; sea as before.
<i>S. Iris</i>	8 P.M. to Mid-night.	...	...	...	...	SW to NW.	...	Fine weather, wind light.
	1 A.M.	...	...	...	...	SSW	...	At 2 A.M., moderate breeze and fine weather.
<i>S. S. Mercedes</i>	Noon	3° 48' N	63° 31' E	...	...	...	...	Pleasant breeze and fine weather; course N 8° W; distance 116 miles.
	7 P.M.	...	...	...	...	SW	...	At mid-night pleasant breeze and cloudy weather.
	1 A.M.	...	...	...	...	W	2	Light breeze and a clear sky. Heavy head sea. Course W by S.
	6 A.M.	...	...	...	...	S	2	
	10 A.M.	...	...	...	...	SE	2	
<i>S. Mistley Hall</i>	Noon	18° 18' N	70° 29' E	...	...	SE	2	Fine weather; continuous head sea; course S 75° W. Distance 138 miles.
	8 P.M.	...	...	...	...	SE	4	Fresh breeze.
	1 A.M.	...	...	29° 830	...	SW by W	...	Moderate breeze and clear weather.
	Noon	10° 39' N	61° 20' E	...	...	...	...	Ditto ditto
	1 P.M.	...	...	29° 810	...	...	...	Course N 39° E. Distance 192 miles.
<i>S. Queen's Cliff</i>	6 P.M.	...	...	29° 770	...	...	...	Every appearance of heavy weather; at 6-30 P.M. strong squall with heavy rain, thunder and lightning.
	10 P.M.	...	...	29° 750	...	...	...	
	4 A.M.	...	...	...	...	SW	...	
	Noon	4° 14' N	56° 22' E	...	...	...	...	Strong breeze and squally; course N 40° E. Distance 151 miles.
	2 P.M.	...	...	...	...	SW	...	Strong breeze.
<i>S. S. Rohilla</i>	Mid-night	...	...	...	...	...	...	Strong breeze with squalls and heavy showers.
	1 A.M.	...	...	...	...	NW	...	At 2 A.M. vivid lightning to SE.
	4 A.M.	...	...	29° 706	87° 0	N	...	Moderate unsteady wind; overcast; lightning to SE.
	6 A.M.	...	...	...	...	N	...	Fresh wind.
	8 A.M.	...	...	29° 828	86° 0	NE	...	Overcast; rising sea; lightning to SW.
	Noon	14° 11' N	53° 58' E	29° 723	91° 0	...	...	Moderate breeze; overcast with slight rain at times. Course N 75° E. Distance 297 miles.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermometer.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. S. Rohilla.</i> — contd.	4 P.M.	...	...	29°649	86°0	...	...	Steady breeze. Fine clear weather.
	8 P.M.	...	...	29°711	85°0	SE	...	Fresh increasing breeze and cloudy weather.
	Mid-night	...	...	29°761	85°0	S	...	Fresh breeze and overcast sky with rain. Rising sea.
<i>S. S. Sestos</i>	1 A.M.	...	...	...	...	W	...	
	4 A.M.	...	...	...	...	W	...	Light airs from west. Fine clear weather. Ship tumbling about a good deal.
	Noon	18° 58' N	70° 51' E	29°724	79°7	...	...	Faint airs; hot weather. Course N 86° W. Distance 13½ miles.
	1 P.M.	...	...	...	...	Calm	...	
	4 P.M.	...	...	...	...	SE	...	Very light wind; weather very hot.
	8 P.M.	...	...	...	...	SE	...	Breeze freshening. Ship lurching and rolling about heavily in the confused and high swell.
	Mid-night	...	...	...	...	ESE	...	Ditto ditto
	4 A.M.	...	...	29°746	81°7	W	...	Moderate breeze; strong south-westerly swell; ship rolling heavily.
	8 A.M.	...	...	29°771	83°7	...	...	Light wind; south-westerly swell; ship rolling very heavily.
<i>S. S. Sirdhana</i>	Noon	20° 24' N	70° 39' E	29°737	88°7	W	...	Light airs; south-westerly swell; ship rolling heavily.
	4 P.M.	...	...	29°800	83°7	...	...	No change.
	8 P.M.	...	...	29°771	83°7	...	...	Ditto.
	Mid-night	...	...	29°793	82°7	...	...	Ditto.
	1 A.M.	...	...	...	...	S	...	
	4 A.M.	...	...	...	...	...	...	Increasing breeze and cloudy weather.
	7 A.M.	...	...	...	...	SW	...	At 8 A.M. brisk breeze and cloudy weather.
	Noon	5° 9' N	61° 53' E	29°860	89°0	SW	...	Ditto ditto Course N 6° E. Distance 143 miles.
	4 P.M.	...	...	...	...	...	...	Brisk breeze and cloudy weather.
<i>S. S. Slieve More</i>	9 P.M.	...	...	...	...	...	...	Cloudy weather with light-ning to N & NE.
	Mid-night	...	...	...	...	...	...	Fresh breeze and cloudy weather.
	4 A.M.	...	...	29°718	...	NW	2	
	8 A.M.	...	...	29°708	...	NW	2	
	Noon	12° 55' N	45° 46' E	29°713	...	NW	2	
	4 P.M.	...	...	29°699	...	NW	2	
	8 P.M.	...	...	...	...	SW	2	
	Mid-night	...	...	...	...	SW	2	
		...	...	...	...	...	...	
<i>S. S. Tebe</i>	4 A.M.	...	...	29°718	...	NW	2	
	8 A.M.	...	...	29°708	...	NW	2	
	Noon	12° 55' N	45° 46' E	29°713	...	NW	2	
	4 P.M.	...	...	29°699	...	NW	2	
	8 P.M.	...	...	...	...	SW	2	
	Mid-night	...	...	...	...	SW	2	

NAME OF VESSEL.	Hours.	Latitude.	Longitude.	Barometer.	Thermo- meter.	Wind.		REMARKS.
						Direction.	Force.	
<i>S. S. Wheatfield</i>	1 A.M.	...	...	...	...	Variable	...	Light airs, and fine weather.
	Noon	13° 58' N	51° 11' E	...	...	...	...	
	8 P.M.	...	...	...	...	N	...	Light breeze and cloudy sky; lightning to the SE.
	Mid-night	...	...	...	...	NE	...	Light breeze and overcast sky.

The pressure fell slightly along the coast of India to the north of Bombay and also in Ceylon, but rose a little along the intermediate coast line. It also fell considerably at Aden. When these changes had taken place, the pressure was still two or three hundredths of an inch above the normal along the whole western coast of India, but in Ceylon it was from three to four hundredths below it, and at Aden it was five hundredths below. In the south-western portion of the sea area the pressure had changed but little since the previous day. If anything, it had risen slightly. But in the middle of the Arabian Sea the barometric depression had assumed much larger proportions than on the 26th, the pressure near the centre having fallen two-tenths of an inch in twenty-four hours, thereby increasing the diameter of the circular isobar of 29.7 from about 150 miles to about 300 miles, and bringing that of 29.5 into view for the first time, with a diameter of about 90 miles. The position of the centre of the depression was very nearly the same as on the previous day, *viz.*, in Lat. 13° 48' N, Long. 66° 56' E. The lowest recorded pressure was about 29.5, as reported by the *Deva Gangadur*, which was about 40 miles to the west of the centre. This is about .35" below the average pressure for the time of the year at the position then occupied by the ship. Simultaneously with this fall of the barometer, the wind increased to a gale from NW with violent squalls of wind and rain, raising a heavy sea which washed away the bulwarks, and otherwise damaged the ship. The *Berengaria*, which was about 115 miles to the NNE of the centre, had a moderate and increasing gale from ENE with heavy squalls and rain, and a "sea" from the eastward; while the *Africa*, which was about 160 miles to the N of the centre, farther away than the *Berengaria*, reported a fresh increasing breeze from NE and cloudy weather with a falling barometer, and later in the day squalls and rain with lightning in the E and SE. Outside the storm area, between it and the equator and to the west of the 64th meridian, the trade wind system had again advanced bodily northward, south-easterly winds now extending as far as 3° N Lat., southerly winds to Lat. 4° N, and south-westerly winds farther northward. The strength of these winds had again increased, and they were now blowing with an average force of 4.7. In the Gulf of Aden the winds were light, and variable in direction, but from Long. 52° E to Long. 62° E along the steamer track from Aden to Bombay they were light and northerly. Along the west coast of India from Bombay to Karachi they were light and south-westerly, from Bombay to Mangalore light and variable, and farther south light and north-westerly. Between the coast and the storm area they blew with the strength of a moderate breeze from southerly directions. Around the storm centre the weather was squally and rainy, every vessel within a distance of 300 miles from the centre having reported to that effect. Rain was not exclusively confined to the storm area, however, for it was also reported by several ships to the north

of Socotra, by several others far away to the south-west, about 1,000 miles from the storm centre, and by the *Mistley Hall* in the intermediate region. The last mentioned vessel, when fully 400 miles from the centre, recorded a strong squall, heavy rain, thunder and lightning, and "every appearance of heavy weather." Rain had also fallen during the preceding twenty-four hours along the Malabar Coast and in Ceylon, but none had fallen to the northward of Karwar, where the weather remained fine and clear.

28th May 1881.—The following tables contain the meteorological information for the 28th.

TABLE XVII.—10 A. M., 28th May 1881.

STATION.	Barometer.	Change in 24 hours.	Abnormal.	WIND.		Thermo- meter.	Relative Humidity.	Cloud.	Rainfall.	Remarks on the weather at 10 A.M.
				Direction.	Velocity* mean of day.					
	"	"	"		Miles per hour.	"	Per cent.	0 to 10.	"	
Zanzibar . .	30.076	—'013	+ '003	WSW	4	77.2	87	1	0.02	
Aden . .	29.736	—'041	—'090	ENE	4	90.2	75	...	...	
Bushire . .	.738	+ '059	+ '040	NW	8	90.8	54	...	...	
Karachi . .	.727	+ '006	+ '038	SSW	?	90.0	65	?	?	
Bhuj . .	.746	+ '020	+ '055	SW	11	91.7	45	0	...	
Rajkot . .	.759	+ '002	+ '038	WNW	17	92.4	44	0	...	
Surat . .	.799	+ '004	+ '027	W	12	92.5	48	0	...	
Bombay . .	.796	—'044	—'014	SSW	10	89.0	64	4	...	Sea rather rough.
Ratnagiri . .	.819	—'025	+ '015	SSW	...	88.0	61	2	0.05	Sea very high.
Karwar . .	.853	+ '012	+ '010	SW	...	83.1	78	6	0.40	Sea rough.
Mangalore . .	.875	—'018	+ '022	SSW	3	84.9	76	5	0.05	
Calicut . .	.889	—'004	+ '009	SSW	5	81.7	86	3	0.04	Sea very rough.
Cochin . .	.898	+ '007	+ '009	NNW	2	86.0	68	2	...	
Colombo . .	?	?	?	SW	10	86.5	69	2	...	
Galle . .	.888	+ '041	+ '010	NW	10	85.0	87	4	0.02	

TABLE XVIII.—28th May 1881.

NAME OF VESSEL.	HOURS.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
S. Africa . .	6 A.M.	...	...	29.659 ^P	...	...	...	Wind and squalls increasing in violence, and all signs of bad weather, bore away about 30 miles to SW and SSW to avoid centre of cyclone. Ship becoming unmanageable, hove-to on port tack. Wind increasing in violence.
	Noon	15° 10' N	66° 50' E	29.679 ^P	...	NNW	...	

NAME OF VESSEL.	Hours.	Latitude.	Longitude.	Barometer.	Thermometer.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. Africa</i> —contd.	4 P.M.	...	...	29°609?	...	...	...	Heavy gale.
	6 P.M.	...	...	...	...	...	...	Storm increasing with tremendous squalls; sea getting more confused.
	7 P.M.	...	...	29°449?	...	NW	...	Wind changing more towards W and SW.
	8 P.M.	...	...	29°159	...	...	...	
	9 P.M.	...	...	29°109	...	...	...	
	9-30 P.M.	...	...	28°999	...	...	...	
	10 P.M.	...	...	28°799	...	SW	...	
	11-30 P.M. Mid-night.	...	...	28°859	...	...	...	
<i>S. Berengaria</i>	6 A.M.	...	...	29°450	...	NNE	...	Wind blowing a tremendous hurricane. Sea mountainous from all directions of the compass. Continual lightning all round and loud peals of thunder. Blinding rain; barometer rising.
	8 A.M.	...	...	29°350	...	...	...	Wind and sea increasing.
	9 A.M.	...	...	29°250	...	...	...	Wind strong and squally.
	9-30 A.M.	...	...	29°150	...	...	...	Fore lower topsail carried away.
	10 A.M.	...	...	...	...	...	...	Gale increasing. Main lower topsail carried away. Blowing a heavy gale. Kept ship away before the wind. Heavy rain.
	Noon	14° 49' N	67° 29' E	29°302	...	W	...	Fierce gale gradually backing to southward. Course N 20° E. Distance 36 miles.
	1 P.M.	...	...	...	...	SW	...	Fierce gale blowing as hard as ever; heavy sea. Ship labouring and shipping much water.
	Mid-night.	...	...	...	...	...	...	Gale moderating.
<i>S.S. Bessie Morris</i>	1 A.M.	...	...	29°726	80°5	SW	3	Moderate breeze and cloudy with high confused sea.
	4 A.M.	...	...	...	...	SW	4	
	9 A.M.	...	...	...	...	SW	5	
	Noon	14° 23' N	56° 36' E	29°818	83°5	SW	5	Brisk breeze and fine weather. Course N 82° E. Distance 225 miles.
	1 P.M.	...	...	...	...	SW	5	Strong breeze and heavy swell from SW.
	6 P.M.	...	...	...	...	SW by W	5	
	2 A.M.	...	...	...	...	S	...	
	10 A.M.	...	...	...	...	SW	...	
<i>S. Braidwood</i>	Noon	4° 22' N	56° 40' E	...	...	...	...	Course N 36° E.
	2 P.M.	...	...	...	...	SW	...	Fine clear weather.
	6 A.M.	...	...	...	...	WSW	...	Squall at 0-30 A.M.
<i>S. British Crown</i>	Noon	9° 5' N	62° 41' E	...	...	...	...	Fresh breeze and squally weather with heavy sea.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. British Crown</i> — contd.	2 P.M.	...	...	...	...	WSW	...	Strong breeze and squally weather.
	8 P.M.	...	...	...	...	...	...	Heavy tumultuous sea. Ship labouring considerably.
<i>S. Choice</i>	Mid- night	...	...	...	...	W	...	Same weather. Ship rolling rails under at intervals.
	Noon	4° 31' N	56° 30' E	29.965	...	SW	...	At 7 P.M. strong breeze and overcast sky.
	4 P.M.	...	...	...	...	SW by W	...	Ditto ditto.
<i>S.S. Clan Alpine</i>	8 P.M.	...	...	...	...	...	...	Strong breeze and squally weather.
	1 A.M.	...	...	29.672?	83.2	NW	...	Moderate breeze and cloudy weather.
	5 A.M.	...	...	...	...	NNW	...	Smart breeze and smooth sea.
	8 A.M.	...	...	29.482?	...	N	...	High southerly sea. Threatening appearance to south-eastward.
	9 A.M.	...	...	...	...	NNE	...	Strong breeze with heavy rain. Squalls at 10 A.M.
	Noon	17° 42' N	65° 50' E	...	...	NNE	...	Cloudy weather. Course N 76° E. Distance 228 miles.
	1 P.M.	...	...	29.462?	82.0	NE	...	Fresh gale with heavy rain, squalls and high cross sea.
	4 P.M.	...	...	...	...	ENE	...	Wind suddenly shifted to ENE in a hard squall.
<i>S.S. Clandon</i>	8 P.M.	...	...	29.332?	...	E by N	...	Fresh gale and overcast sky. Less sea.
	Mid- night	...	...	29.292?	...	E by N	...	Fresh gale with hard squalls and rain.
	1 A.M.	...	...	...	...	SW	...	Light breeze and clear weather.
	9 A.M.	...	...	...	...	WSW	...	Ditto ditto.
	Noon	13° 0' N	48° 25' E	...	...	WSW	...	Ditto ditto.
	5 P.M.	...	...	...	...	Variable	...	
	Mid- night	...	...	...	...	...	...	Light variable winds.
<i>S. Cypromene</i>	Noon	17° 51' N	72° 10' E	...	...	S	...	Fine breeze and clear weather; course N 34° E. Distance 138 miles.
<i>S. Deva Gangadur</i>	5 A.M.	...	...	...	...	...	...	Gale moderating.
	Noon	13° 35' N	66° 40' E	29.595	...	...	...	Ship rolling very heavily, and taking large quantities of water on deck; course N 79° E. Distance 36 miles.
	2 P.M.	...	...	...	...	W	...	Blowing a moderate gale, with heavy squalls of wind and rain.
	8 P.M.	...	...	...	...	...	...	A heavy sea rolling from the northward, setting the ship to the southward at the rate of 14 miles per hour. The ship heading due north, but plunging very heavily.
<i>S. S. Ellora</i>	4 A.M.	...	...	...	84.0	SW	...	Light wind and fine weather.
	8 A.M.	...	...	...	85.0	Calm	...	Fine weather. Heavy SW swell.
	Noon	20° 59' N	69° 52' E	...	86.0	Calm	...	Ditto ditto. Course S 44° E. Distance 228 miles.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	Wind.		REMARKS.
						Direction.	Force.	
<i>S. S. Ellora—contd.</i>	4 P.M.	...	...	...	85°0	S	...	Light breeze and heavy southerly swell.
	8 P.M.	...	...	...	82°0	S	...	Ditto ditto.
	Mid- night.	...	...	...	82°0	S	...	Ship rolling violently.
<i>S. S. Eschol</i>	2 A.M.	...	...	...	...	...	...	Moderate breeze with heavy southerly swell.
	8 A.M.	...	...	...	...	...	...	Light airs.
	8 A.M.	...	...	...	...	ENE	...	Variable light airs.
<i>S. S. Euphrates</i>	Noon	14° 4' N	51° 12' E	29°602	...	...	...	Variable light breeze.
	2 P.M.	...	...	...	...	ENE	...	Light airs with hot sultry weather.
	8 P.M.	...	...	...	...	SE	...	Moderate breeze at 8-30 P.M.
	Mid- night.	...	...	...	...	S	...	Moderate breeze with a heavy SW swell.
	4 A.M.	...	...	29°785	81°1	SW	...	Moderate breeze and clear sky.
	8 A.M.	...	...	29°865	87°1	Calm	...	...
	Noon	At Cutch	Mandvi.	...	...	...	...	...
	4 P.M.	...	...	29°785	81°1	W	...	...
	8 P.M.	...	...	29°805	83°1	Calm	...	...
	Mid- night.	...	...	29°805	79°1	Calm	...	Cloudy weather.
<i>S. Exporter</i>	Noon	6° 55' N	61° 0' E	...	...	SW	...	Fresh wind and squally weather.
<i>S. Hindustan</i>	3 A.M.	...	...	...	...	SW by W	...	Wind shifted in a squall from S to SW with heavy rain.
	5 A.M.	...	...	...	...	S	...	Wind shifted back again to the southward.
	8 A.M.	...	...	...	...	WSW	...	Heavy rain.
	9 A.M.	...	...	...	...	WNW	...	...
	Noon	4° 55' N	58° 26' E	...	...	WSW	...	Thick drizzling rain and strong breeze; course N50° E. Distance 176 miles.
	1 P.M.	...	...	...	...	SW by S	...	Fresh breeze and drizzling rain up to 3 P.M.
	4 P.M.	...	...	...	...	SW	...	Steady breeze and fine clear weather.
	8 P.M.	...	...	...	...	...	...	Strong breeze and cloudy.
	Mid- night.	...	...	...	...	SW	...	Strong monsoon with rain.
	1 A.M.	...	...	...	...	SW to NW	...	Moderate breeze. SW sea. Sky partly clouded.
<i>S. S. Inchulva</i>	8 A.M.	...	...	...	...	NW	...	Fresh breeze; SW swell; cloudy weather.
	Noon	16° 36' N	63° 47' E	29°694	...	NW	...	Ditto ditto ditto. Course N 60° E. Distance 205 miles.
	6 P.M.	...	...	...	...	W	...	Light wind; heavy swell from SW.
	8 P.M.	...	...	29°674	...	...	...	...
	Mid- night.	...	...	29°694	...	N	...	Thunder distinct but distant. Very heavy rain. Wind light. Sea as before.
	1 A.M.	...	...	...	...	SW	...	Barometer steady. Smart steady breeze and cloudy weather.
	Noon	6° 39' N	63° 25' E	29°797	...	SW	...	Ditto ditto. Course N 2° W. Distance 171 miles.
<i>S. Iris</i>								

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. Iris</i> —contd.	3 P.M.	...	...	...	...	...	...	Squally.
	9 P.M.	...	...	...	...	WSW	...	Fresh breeze and squally. Lightning in the NW quarter.
<i>S. S. Mercedes</i>	1 A.M.	...	...	...	...	ESE	6	Strong breeze and cloudy weather. A heavy confused sea running. Ship labouring heavily and shipping vast quantities of water.
	5 A.M.	...	...	...	...	E	6	Ditto ditto.
	Noon	17° 41' N	67° 39' E	29.784	84.0	E	7	Strong gale with a heavy confused sea from SE; course S 78° W. Distance 174 miles.
	4 P.M.	...	...	...	...	E	8	Violent squalls of wind and rain.
<i>MS. Istley Hall.</i>	8 P.M.	...	...	...	...	E by N	8	
	Mid-night.	...	...	...	...	ENE	8	
	1 A.M.	...	...	29.730	...	WSW	...	Strong freshening breeze and overcast sky.
	4 A.M.	...	...	29.710	...	WSW	...	
	8 A.M.	...	...	29.670	...	W	...	Strong breeze and overcast sky.
	Noon	13° 59' N	64° 6' E	29.640	...	W	...	Ditto ditto. Course N 39° E. Distance 212 miles.
	3 P.M.	...	...	...	...	WNW	...	Fresh gale and squally weather.
	6 P.M.	...	...	...	...	...	...	Torrents of rain with terrific squalls.
	8 P.M.	...	...	29.610	...	WNW	...	Freshening gale and squally weather. Ship rolling and straining heavily. Shipping large quantities of water.
	Mid-night.	...	...	29.570	...	WNW	...	
<i>S. S. Nyansa</i>	3 A.M.	...	...	30.063	75.3	ESE	3 to 4	Moderate breeze and cloudy weather.
	7 A.M.	...	...	30.023	79.3	...	...	Ditto ditto.
	11 A.M.	...	...	30.017	81.3	SE	3 to 4	
	Noon	0° 28' N	46° 38' E	...	...	...	...	Moderate breeze and fine clear weather. Course N 54° E. Distance 264 miles.
	3 P.M.	...	...	30.020	80.3	SE	3 to 4	Moderate breeze and fine clear weather.
	7 P.M.	...	...	30.036	77.3	SE	2 to 3	Slight breeze and fine weather.
	9 P.M.	...	...	...	...	SSE	...	Ship rolling to SW swell.
	11 P.M.	...	...	30.023	75.3	SSE	2 to 3	Squally with rain.
	Mid-night.	...	...	...	...	...	...	Light unsteady breeze and cloudy weather with rain at times, c. g. p.
	4 P.M.	At Karachi		29.775	81.6	SW	4	Moderate breeze and fine weather.
<i>S. S. Punjab</i>	8 P.M.	Karachi to Bombay		29.775	79.6	WSW	4	Moderate breeze and fine weather. Course S ½ E; speed 9.3 knots.
	Mid-night	...	...	29.755	76.6	WSW	4	Moderate breeze and fine weather.

NAME OF VESSEL.	HOUR.	Latitude.	Longitude.	Barometer.	Thermometer.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. Queen's Cliff</i>	Noon	4° 14' N	58° 3' E	...	...	SW	...	Strong breeze and squally. Ship rolling and labouring heavily. Course N 40° E. Distance 154 miles.
	Mid-night	...	...	...	...	...	...	Strong breeze with heavy squalls and showers.
<i>S. S. Rohilla</i>	4 A.M.	...	...	29.709	86.0	S	...	Moderate breeze and overcast sky.
	8 A.M.	...	...	29.730	85.5	SSW	...	Fresh breeze and overcast sky. Ship rolling to southerly sea.
	Noon	15° 34' N	58° 51' E	29.731	89.0	SW	...	Light monsoon. Moderate sea. Ship rolling to SW swell. Course N 74° E. Distance 300 miles.
	4 P.M.	...	...	29.699	86.0	SW	...	Light breeze and fine weather.
	8 P.M.	...	...	29.706	85.0	SW	...	Moderate monsoon and fine weather.
	Mid-night	...	...	29.709	86.0	W by S	...	Moderate monsoon and fine weather with passing clouds. Almost continuous sheet lightning.
<i>S. S. Sestos</i>	4 A.M.	...	...	...	...	ESE	...	Wind light and steady.
	8 A.M.	...	...	...	...	E	...	Moderate breeze.
	Noon	18° 33' N	67° 51' E	29.714	80.4	E	...	Moderate breeze with passing showers. Course 72° W. Distance 175 miles.
	4 P.M.	...	...	...	...	E	...	Moderate breeze and showery weather.
	8 P.M.	...	...	...	...	E by N	...	Moderate breeze and cloudy weather.
	9 P.M.	...	...	...	...	ENE	...	High cross swell. Lightning to W.
<i>S. S. Sirdhana</i>	1 A.M.	Bombay to Karachi		...	...	W	...	Moderate breeze and strong south-westerly swell. Ship rolling heavily.
	4 A.M.	...	...	29.786	81.7	...	...	Ditto ditto.
	8 A.M.	...	...	29.803	82.7	...	...	Light breeze and strong south-westerly swell.
	Noon	22° 46' N	68° 1' E	29.795	85.7	...	...	Ditto ditto; course N 46° W. Distance 204 miles.
	1 P.M.	...	...	...	...	SW	...	Light airs; heavy south-westerly swell; ship rolling heavily.
	4 P.M.	...	...	29.745	85.7	...	...	Ditto ditto.
	8 P.M.	...	...	29.761	83.7	...	...	Ditto ditto.
	Mid-night.	...	...	29.753	82.7	...	...	Ditto ditto.
<i>S. Sleeve More</i>	4 A.M.	...	...	...	...	SW	...	Fresh breeze and cloudy weather with continual lightning.
	Noon	8° 53' N	64° 51' E	29.820	...	SW	...	Heavy squall; course N 10° E. Distance 237 miles.
	4 P.M.	...	...	...	...	...	...	Strong wind and heavy squalls with misty weather.
	6 P.M.	...	...	...	...	...	...	Sunsets on 26th, 27th and 28th most gorgeous and variegated.
	8 P.M.	...	...	...	...	SW	...	Heavy squalls with continual lightning in N.W.
	Mid-night.	...	...	...	...	...	...	Squally weather. Heavy sea.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. S. Tebe</i>	Noon	13° 44' N	49° 24' E	...	...	SW	2	
	8 P.M.	...	...	29° 68.9	...	SW	2	
<i>S. S. Tenasserim</i>	8 A.M.	...	...	29° 77.6	83.7	Variable	1	Very heavy westerly swell; vessel rolling heavily.
	Noon	15° 31' N	72° 35' E	29° 79.0	86.2	S	1	
	1 P.M.	...	...	...	...	S	2 to 3	Heavy southerly swell.
	4 P.M.	...	...	29° 70.6	82.7	S	3	
	8 P.M.	...	...	29° 78.0	90.7	S	3 to 4	Heavy swell from south- ward; vessel rolling heavily.
	Mid- night.	...	...	29° 77.8	90.7	SW	2 to 3	Vessel rolling heavily.
<i>S.S. Wheatfield</i>	1 A.M.	...	...	...	...	NE	...	Light breeze and overcast sky.
	8 A.M.	...	...	...	...	E	...	Light breeze and fine weather.
	Noon	15° 7' N	54° 29' E	...	...	SW	...	
	4 P.M.	...	...	...	...	...	...	Light breeze and cloudy sky with heavy SW swell.
	Mid- night.	...	...	...	...	...	...	Light breeze and fine weather. Heavy south- west swell; ship rolling heavily.
<i>S. S. Wistow Hall</i>	Noon.	12° 26' N	44° 9' E	29° 78.1	84.2	W	...	Fresh breeze and clear weather.
	7 P.M.	...	...	...	...	SE	...	Slight breeze and cloudy weather.
	Mid- night.	...	...	...	...	...	...	Light breeze and clear weather.

The chart for the day, Plate XXIX, represents the meteorological conditions at noon. It shows that the cyclonic depression of the barometer had deepened very much during the preceding twenty-four hours, and that the centre had moved to the northward to about Lat. 15° 9' N, Long. 67° 28' E. At the same time the winds around it had become very much stronger than on the previous day, and were now blowing with great violence. The lowest pressure marked on the chart is 29.3" at a distance of about 25 miles from the centre. Four and a half hours before noon, however, the *Berengaria*, which was then nearer to the centre than at noon, recorded a pressure of 29.15", which is 0.68" below the normal pressure for the time of the year. Later in the day, at 10 P.M., the *Africa*, when not very far from the centre, probably about 12 miles off, recorded a pressure of 28.8," which is the lowest in the records for the day, and about 1.03 inch below the normal pressure. The circular isobar of 29.7 had widened in diameter in the course of the twenty-four hours from about 380 miles to about 440 miles, and the diameter of the isobar of 29.5 had increased from about 90 miles to about 150 miles. Along the west coast of India from Bombay to Calicut, the pressure had fallen slightly, but farther to the north and south, it had risen somewhat. Still it was slightly above the normal at every coast station except Bombay, where a trifling depression had appeared. In the Arabian Sea to the south of the parallel of 10° N it had also risen, the isobar of 29.9 having moved one or two degrees northward, and that of 30.0 having made its appearance in the extreme south, for

the first time since the formation of the cyclonic vortex. At Aden, however, the pressure had fallen about four hundredths of an inch, and was now about nine hundredths below the normal.

At noon, the *Berengaria*, which was then about 25 miles to the south of the centre, recorded a fierce gale from W, gradually backing to southward as the cyclone moved towards the north-west. An hour later, the wind was from SW, blowing as hard as ever, but by midnight it had begun to moderate. Heavy rain was recorded at 10 A.M., and a heavy increasing sea throughout the day. The *Africa*, which at noon was about 50 miles to the west-north-west of the centre, was obliged to "heave to" on account of the violence of the wind, which was then blowing from the NNW. At 4 P.M. the wind had increased to a heavy gale, and at 6 P.M. it was still increasing with tremendous squalls, a confused sea, and a rapidly falling barometer. At 7 P.M. the wind was from NW; afterwards it backed to W and SW, and at 10 P.M., when the barometer was lowest, it was from SW. At midnight, when the barometer had begun to rise, the wind was "blowing a tremendous hurricane," the sea was mountainous, running from all directions of the compass, and there was continual lightning all round with loud peals of thunder and "blinding rain." The *Deva Gangadur*, which was about 120 miles to the south-west of the centre at noon, reported that at 5 A.M. the gale was moderating, but at 2 P.M. it was still recorded as a moderate gale from W with heavy squalls of wind and rain. At 8 P.M., a heavy sea from northward is recorded without any change of wind direction. Here again it is noteworthy that the direction of the sea was several points to the right of that of the wind. The *Mercedes*, which at noon was about 140 miles to the northward of the centre, reported a strong gale from E with a heavy confused sea from SE, again from a direction several points to the right of the wind. The wind increased in strength as the day advanced, and slowly backed to ENE. This shows that the vessel was passing through the northern half of the storm field, going from east to west, and steaming westward at a greater speed than that at which the storm was travelling. In fact the vessel was gradually overtaking the storm, and as the storm field was at the time moving north-westward, the ship was crossing the storm path, and so getting nearer and nearer to the centre. At 8 P.M. she experienced violent squalls of wind and rain. The *Sestos*, also homeward bound, had a very similar experience. At 4 A.M. she had a light wind from ESE. At noon the wind had increased to a moderate breeze, and had backed to E with cloudy showery weather. At 9 P.M. it had backed to ENE. At noon this vessel was about 230 miles to the northward of the centre, much farther away than the *Mercedes*. The winds were therefore relatively feeble. The *Clan Alpine* also passed through the northern half of the storm field, but as she was outward bound, going from west to east, the shift of the wind was observed in the opposite direction, viz., from NW at 1 A.M. round by N at 8 A.M., to ENE at 4 P.M., the wind gradually increasing in strength from a moderate breeze to a fresh gale with hard squalls and heavy rain. At 8 A.M., when the wind was from N, a high southerly sea was recorded and a threatening appearance to the south-eastward in the direction of the storm centre. The weather was cloudy throughout the day, and heavy rain fell at intervals. The *Mistley Hall*, which at noon was about 230 miles to the west-south-west of the centre, reported a strong freshening breeze and an overcast sky from 1 A.M. to noon, the wind in the early part of the day being from WSW, but veering later to W and WNW under the influence of the cyclone, and increasing to a fresh gale from WNW in the

afternoon with "torrents of rain" and "terrific squalls," the barometer falling gradually from 29·73 at 1 A.M. to 29·57 at midnight. The *Inchulva*, which at noon was about 270 miles to the WNW of the centre, and directly in front of it, reported light north-westerly winds for the greater part of the day, and very heavy rain, with distinct but distant thunder at midnight.

There is ample evidence to show that outside the storm field to the south-west, between the storm and the equator, the south-westerly winds had again increased in strength, the average force from the observations of eight vessels having now risen to 5·2 on Beaufort's scale, in accordance with the increase of the barometric gradients resulting from the fall of pressure in the storm area and the rise in the extreme south. There is also consistent evidence from four vessels to the northward of Socotra to show that the south-westerly winds had advanced much farther northward than on the 27th, the winds in this region having now become south-westerly, whereas on the previous day they had been north-westerly. Between the storm field and the Bombay coast, the winds were light and southerly as on the previous day.

The storm had now begun to make itself felt on the west coast of India; the winds from Bombay to Calicut having become south-south-westerly, and the sea on the same portion of the coast having become very rough. These were the first signs on land of the existence of rough weather out at sea, but there were no indications which pointed decidedly to the actual formation of the cyclone.

On the same part of the west coast of India the weather was cloudy, but little or no rain had fallen; the greatest amount having been a local fall of four-tenths of an inch at Karwar. Farther to the north and south, the weather was comparatively clear. There was, as shown by the chart, a remarkable concentration of rainfall over the storm field, the weather conditions presenting, in this respect, a marked contrast with those of the previous day, rain having virtually ceased on the west coast, to the north of Socotra, and to the southward of the storm area. Heavy rain was reported, however, by two ships between latitudes 4° and 5°S, and passing showers by one near the equator.

1881, May 29.—The following tables contain the meteorological data for the 29th:—

TABLE XIX.—10 A.M., 29th May 1881.

STATION.	Barometer.	Change in twenty-four hours.	Abnormal.	WIND.		Thermo- meter.	Relative Humid- ity.	Cloud.	Rainfall.	Remarks on the weather at 10 A.M.
				Direction.	Velocity Mean of day, Miles per hour.					
Zanzibar . . .	30·104	+·038	+·028	SW	5	79°0	79	3	...	
Aden . . .	29·740	+·004	—·083	NNE	7	91·2	72	...	...	
Bushire . . .	743	+·005	+·051	NW	18	86·8	58	...	...	
Karachi . . .	73	+·010	+·052	SW	13	90°0	63	0	...	
Bhuj . . .	739	—·007	+·051	SSW	9	95·4	44	0	...	
Rajkot . . .	750	—·009	+·033	S	10	95·1	44	2	...	
Surat . . .	790	—·009	+·021	W	14	93·5	49	0	...	

STATION.	Barometer.	Change in twenty-four hours.	Abnormal.	WIND.		Thermo- meter.	Relative Humid- ity.	Cloud.	Rainfall.	Remarks on the weather at 10 A.M.
				Direction.	Velocity Mean of day.					
	"	"	"		Miles per hour.	"	Percent.	0 to 10	"	
Bombay . . .	800	+004	-007	S	25	87.4	68	7	...	Sea rough.
Ratnagiri . . .	827	+008	+025	S	...	90.1	59	0	...	
Karwar . . .	855	+002	+013	SW	...	84.8	76	5	0.39	
Mangalore . . .	891	+016	+038	S	4	84.9	74	6	0.46	Sea rough.
Calicut . . .	P	P	P	WNW	4	80.7	81	6	0.12	
Cochin . . .	914	+016	+024	NNW	1	82.5	85	7	0.10	
Colombo . . .	895	?	+007	SW	9	87.0	71	3	...	
Galle . . .	893	+005	+015	NW	11	84.0	91	6	...	

TABLE XX—29th May 1881.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. Africa</i>	3 A.M.	...	...	29.259	...	...	...	Storm gradually decreasing in strength. Less lightning, thunder and rain.
	6 A.M.	...	...	29.359	...	...	...	
	Noon	...	...	...	...	...	...	Mountainous sea from SW.
	4 P.M.	...	...	29.509	...	...	...	Weather more moderate.
<i>S. Berengaria</i>	6 A.M.	...	...	...	...	...	...	Barometer rising fast.
	Noon	16° 36' N	69° 47' E	29.650	...	SE	...	Moderate weather. Course N 51° E. Distance 152 miles.
<i>S. S. Bessie Morris</i>	1 A.M.	...	...	29.826	80.5	SW by S	6	Strong breeze and cloudy weather with heavy SW swell.
	6 A.M.	...	...	...	...	WSW	6	
	Noon	15° 10' N	60° 48' E	29.862?	85.5	WSW	6	Sky overcast Course N 79° E. Distance 247 miles.
	1 P.M.	...	...	29.718	...	WSW	7	Brisk gale and heavy squall with rain and high sea.
	5 P.M.	...	...	...	...	WSW	8	Increasing gale with very heavy squall and rain.
	6 P.M.	...	...	29.669	...	WSW	8	
	Midnight.	...	...	29.519	...	WSW	9	Heavy gale with high sea; squalls and rain.
<i>S. Braidwood</i>	4 A.M.	...	...	...	...	SW	...	
	Noon	6° 59' N	58° 43' E	...	...	...	...	Course N 36° E.
	2 P.M.	...	...	...	...	SW	...	Moderate breeze and cloudy weather with showers of rain.
	Midnight.	...	...	...	...	...	...	Fine clear weather.
<i>S. British Crown</i>	8 A.M.	...	...	...	...	W	...	Moderate breeze.
	10 A.M.	...	...	...	...	W by N	...	
	Noon	11° 47' N	84° 8' E	...	...	...	...	

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermometer.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. British Crown</i> —continued.	2 P.M.	...	...	...	...	W	...	Fresh breeze and cloudy weather.
<i>S. S. Burmah</i>	4 A.M.	Bombay	to Karachi	...	84.6	Calm	...	High swell. Ship rolling heavily.
	8 A.M.	...	...	...	86.6	Variable	...	
	Noon	At Cutch	Māndvi	...	87.6	Variable	...	Light breeze and fine weather.
	4 P.M.	...	...	...	86.6	SW	...	
	8 P.M.	...	...	...	87.6	...	...	Moderate breeze with heavy SW swell.
	Mid-night.	...	...	...	85.6	...	...	Light breeze and cloudy weather.
<i>S. Choice</i>	8 A.M.	...	...	...	...	SW	...	Strong breeze and showery weather.
	Noon	6° 37' N	58° 6' E	30.065	...	...	...	Course N 33° E.
	1 P.M.	...	...	...	...	SW	...	Strong breeze and showery weather.
	8 P.M.	...	...	...	...	SW	...	Strong breeze and heavy squalls.
<i>S. S. Clan Alpine.</i>	1 A.M.	...	...	...	...	ENE	...	Heavy gale with furious squalls.
	4 A.M.	...	...	29.362	...	E to ESE	...	Hard gale with furious squalls and high southerly sea.
	5 A.M.	...	...	...	...	E	...	Ditto ditto.
	8 A.M.	...	...	29.412	...	ESE	...	Ditto ditto.
	Noon	18° 18' N	67° 48' E	29.492	84.0	SE	...	Heavy gale and high cross sea. Course N 76° E. Distance 172 miles.
	4 P.M.	...	...	...	...	...	...	Gale decreasing. Cloudy weather, and a heavy sea.
	7-30 P.M.	...	...	...	...	...	...	Less wind and clear weather.
	8 P.M.	...	...	...	...	...	...	Strong breeze and a clear sky.
	Mid-night.	...	...	29.692	...	...	...	Ditto ditto.
<i>S. S. Clandon</i>	1 A.M.	...	...	...	...	W	...	Strong breeze and cloudy weather.
	Noon	14° 7' N	55° 13' E	...	...	W	...	Strong wind and sea. Course E by N ½ N.
	1 P.M.	...	...	...	...	W	...	Strong wind and heavy sea. Ship rolling heavily.
<i>S. Deva Gangadur</i>	8 A.M.	...	...	...	...	...	...	Ship rolling very heavily.
	Noon	13° 28' N	67° 2' E	29.395	...	...	...	Gale moderating. Course S. Distance 36 miles.
	2 P.M.	...	...	...	...	SW	...	
	Mid-night.	...	...	...	...	...	...	Squally with heavy showers of rain.
<i>S. S. Eschol.</i>	6 A.M.	...	...	...	...	SW	...	Moderate breeze with a heavy swell from SW.
	Noon	14° 42' N	54° 31' E	29.602	...	...	...	Fresh breeze and very warm weather. Course E by N. Distance 202 miles.
	2 P.M.	...	...	...	...	SW	...	Fresh breeze with a swell from the SW.
	Mid-night.	...	...	...	...	...	...	Strong wind with heavy swell.
<i>S. S. Euphrates</i>	4 A.M.	...	...	29.785	81.1	SE	...	Moderate breeze and hazy weather. Heavy SW swell.
	8 A.M.	...	...	29.815	83.1	...	...	At 9-30 A.M., moderate breeze and high sea.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. S. Euphrates</i> —continued.	Noon	21° 15' N	69° 49' E	29° 845	85° 1	SE	...	Fresh breeze and clear with a heavy SW swell. Course SE by E. Distance 31 miles.
	4 P.M.	...	...	29° 785	85° 1	S	...	Fresh breeze with a heavy SW sea. Ship rolling heavily.
	8 P.M.	...	...	29° 845	83° 1	S	...	Ditto ditto.
	Mid- night.	...	...	29° 845	79° 1	S	...	Ditto ditto.
<i>S. Exporter</i> .	Noon	9° 33' N	63° 11' E	...	...	SW	...	Squally weather. Course NE by N.
<i>S. Hindustan</i>	4 A.M.	...	...	...	...	...	...	Strong breeze and clear weather.
	8 A.M.	...	...	...	...	SW	...	Strong monsoon.
	Noon	7° 25' N	60° 34' E	...	...	SW	...	Strong monsoon. Course N 40° E. Distance 196 miles.
	4 P.M.	...	...	...	...	...	...	Squally appearance in the westward.
	10 P.M.	...	...	...	...	SW	...	Strong squalls with rain.
	Mid- night.	...	...	...	...	...	...	Strong breeze and fair weather.
<i>S. S. Inchuiva</i>	1 A.M.	...	...	...	...	N	...	Light wind coming in hot gusts, probably from the heated land to the northward. Cloudy weather. Thunder and lightning at intervals.
	4 A.M. to 6 A.M.	...	...	...	...	...	...	Very heavy blinding rain.
	6 A.M.	...	...	...	...	...	...	Weather looking dirty. Sun rising red and fiery.
	8 A.M.	...	...	...	...	N	...	Strong gale. Ship hauled up to the N and engines going half speed.
	9 A.M.	...	...	...	...	...	...	First indication of an advancing cyclone.
	10 A.M.	...	...	...	...	NE	...	Wind blowing hard. Barometer falling fast.
	11 A.M.	...	...	...	...	NE	...	Cyclone blowing with terrific violence, carrying every thing before it. Wind increasing.
	Noon	...	...	...	...	NE	...	Terrific wind, steady at NE, blowing to atoms every thing it can reach.
	2 P.M.	...	...	27° 15	...	Calm	...	In the centre of the cyclone. Calm with a fearful boiling sea. Heavy hanging clouds to SW.
	2-40 P.M.	...	...	...	...	SW	...	Light wind from SW increasing in a few minutes to greater violence than that of the wind from NE. Rain falling in torrents. The howling of the wind destroys every other sound. Barometer rising; rose to 28 inches in less than one hour.
	3-20 P.M.	...	...	...	...	SW	...	Wind blowing the hardest, with torrents of rain through which it is impossible to see more than ten feet.
	4 P.M.	...	...	...	...	SW	...	Wind a little less violent.

NAME OF VESSEL.	HOUR.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. S. Inchulwa</i> —continued.	5 P.M.	...	...	28°20	...	SSW	...	
	6 P.M.	...	...	28°60	...	...	...	
	8 P.M.	...	...	28°80	...	...	...	Very heavy rain and terrific gusts of wind.
	10 P.M.	...	...	...	...	S	...	Wind blowing very hard.
	11 P.M.	...	...	29°10	...	S	...	Wind blowing very hard with very heavy squalls and rain. Weather improved. A tremendous sea from all directions.
<i>S. Iris.</i>	1 A.M.	...	...	...	...	W by S	...	Fresh breeze and cloudy weather; squalls and rain; heavy squall at 1-30 A.M.; 8 A.M., strong breeze and squalls.
	Noon	10° 0' N	64° 8' E	29°757	...	...	...	Fresh breeze and cloudy weather. Course N 12° E. Distance 205 miles.
	1 P.M.	...	...	...	...	WSW	...	Strong winds with heavy squalls and rain.
	2 P.M.	...	...	...	...	...	...	Wind more moderate.
	Mid- night.	...	...	...	...	...	...	Strong wind and squally.
<i>S. S. Mercedes</i>	1 A.M.	...	...	...	...	ENE	8	Strong gale with a heavy confused sea.
	6 A.M.	...	...	...	...	NE	9	Same weather and sea with heavy squalls of wind and rain. Unable to see more than a few yards ahead of the ship at times.
	Noon	17° 40' N	64° 11' E	29°474	89°1	NNE	9	Furious gale with a fearful heavy confused sea. Course W. Distance 200 miles.
	1 P.M.	...	...	...	...	NNE	10	
	2 P.M.	...	...	...	...	NNE	10	
	3 P.M.	...	...	...	...	N by E	10	
	4 P.M.	...	...	...	...	N	10	A heavy squall and a sea struck the ship on the star-board border, heaving her on her port beam ends, and washing about 15 tons of coal off the deck. Ship righted a little, but still has a strong list to port. Every appearance of having been close to the centre of a cyclone travelling towards the NW.
	5 P.M.	...	...	...	...	N	11	
	6 P.M.	...	...	29°282	...	N	12	Wind blowing with terrific force and ship labouring greatly, and shipping vast quantities of water, washing every thing moveable overboard.
	7 P.M.	...	...	...	...	N	12	
	8 P.M.	...	...	29°268	...	N by W	12	Wind and sea terrific. Heavy squalls of rain. Sea confused and ship completely under water fore and aft.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. S. Mercedes— contd.</i>	9 P.M.	...	...	...	...	N by W W	12	Wind and sea as before. Vessel labouring very heavily.
	10 P.M.	...	...	29°323	...	NNW	12	
	11 P.M.	...	...	...	...	NNW	12	
	Mid- night.	...	...	29°362	...	NW by N	12	
<i>S. Mistley Hall</i>	1 A.M.	...	...	29°550	...	WNW	...	Furious hurricane with terri- fic sea. Ship seems to be in a perilous condition.
	5 A.M.	...	...	29°540	...	NW	...	Freshening gale with terri- fic squall.
	9 A.M.	...	...	29°410	...	...	...	Terrific gale with fearful sea.
	Noon	15° 15' N	66° 22' E	29°310	...	WSW	...	Terrific gale with fearful sea. Course N 45° E. Distance 190 miles.
<i>S. S. Nyansa</i>	6 P.M.	...	...	...	...	SW	...	Gale moderating but sea high and confused.
	1 A.M.	...	...	30°045	74°3	SE by S	...	Light breeze and cloudy weather.
	7 A.M.	...	...	30°037	77°3	SE	4	Cloudy weather.
	11 A.M.	...	...	30°024	82°3	SE	4	
	Noon	2° 37' N	50° 22' E	...	...	SE	4	Moderate breeze and fine clear weather. Course N 54° E. Distance 266 miles.
	3 P.M.	...	...	30°020	80°7	SE	4	Moderate breeze and fine clear weather.
	5 P.M.	...	...	...	...	S	3 to 4	Ship rolling heavily.
	7 P.M.	...	...	30°018	77°3	S	3 to 4	Moderate breeze and cloudy weather.
	11 P.M.	...	...	30°023	75°3	S	3 to 4	Ditto ditto.
	4 A.M.	Karachi to Bombay		29°765	75°6	W	2	Light breeze and fine weather.
<i>S. S. Punjab</i>	8 A.M.	...	...	29°755	79°6	Calm	0	Calm and fine. South- westerly swell.
	Noon	22° 19' N	68° 26' E	29°795	81°6	E	2	Course S 31° E. Distance 468 miles.
	4 P.M.	...	...	29°775	82°6	S	5	Fresh breeze and fine weather, heavy southerly sea. Ship plunging heavi- ly.
	8 P.M.	...	...	29°775	79°6	S	5	Ditto ditto.
	Mid- night.	...	...	29°755	74°6	S	4	Moderate breeze and fine weather. Ship pitching to heavy swell.
	Noon	8° 24' N	59° 54' E	...	...	SW	...	Strong breeze and clear weather. Course N 48° E. Distance 172 miles.
<i>S. Queen's Cliff</i>	2 P.M.	...	...	...	...	SW	...	Fresh gale. Ship rolling and labouring heavily, and shipping large quantities of water.
	Mid- night.	...	...	...	...	...	...	Heavy squalls and showers.
	4 A.M.	...	...	29°654	88°0	W by N	...	Moderate breeze and over- cast sky. Sea from WSW.
<i>S. S. Rohilla</i>	7 A.M.	...	...	...	...	WNW	...	Rather sharp squalls.
	8 A.M.	...	...	29°590	86°0	W by N	6	Strong monsoon; overcast sky; rain; high sea.
	10 A.M.	...	...	...	...	WNW	...	
		...	...	...	...	...	...	

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermometer.	WIND.		REMARKS.
						Direction.	Force.	
S. S. Rohilla—contd.	Noon	16° 46' N	63° 53' E	29° 515	84° 0	WNW	9	Strong gale with heavy squalls of wind and rain. High confused sea from northward. Course N 76° E. Distance 300 miles.
	1 P.M.	...	...	29° 465	...	NW	9	Threatening appearance. Concluded that a cyclone was passing ahead and to northward.
	2 P.M.	...	...	29° 415	...	NW	10	High confused sea.
	3 P.M.	...	...	29° 215	...	W	11	
	3:30 P.M.	...	...	29° 195	...	W	11	Wind backed to west. Stood to the ESE to increase distance from the centre of the cyclone.
	4 P.M.	...	...	29° 215	...	W by S	11	Terrific gusts of wind and very high confused sea. Ship lurching very heavily and taking much water over fore and aft.
	5 P.M.	...	...	29° 235	...	WSW	12	
	6 P.M.	...	...	29° 315	...	SW	11	Terrific gusts of wind with a very high confused sea. Ship labouring very heavily and taking water over fore and aft.
	7 P.M.	...	...	29° 365	...	SW	11	
	8 P.M.	...	...	29° 436	80° 0	SW	10	Heavy gale with very heavy sea. Ship labouring and rolling very heavily.
	9 P.M.	...	...	29° 446	...	SW	9	Sea and wind moderating a little; violent squalls of wind and rain at intervals.
	10 P.M.	...	...	29° 566	...	SW	8	Kept ship away on course. Lightning to SE.
	11 P.M.	...	...	29° 586	...	SW	...	
	Midnight.	...	...	29° 606	...	SW	...	Gale of wind and heavy rain.
S. S. Rosetta	4 A.M.	...	...	29° 823	82° 1	W	...	Moderate breeze and fine weather with passing clouds.
	8 A.M.	...	...	29° 876	81° 1	...	...	Ditto ditto ditto.
	Noon.	7° 27' N	77° 58' E	29° 853	82° 1	W by S	...	Fresh breeze and fine weather.
	4 P.M.	...	...	29° 765	85° 1	...	...	
	8 P.M.	...	...	29° 836	81° 1	...	...	Light wind and fine weather.
S. S. Sestos	Midnight.	...	...	29° 870	83° 1	...	...	Ditto ditto ditto.
	1 A.M.	...	...	...	...	ENE	...	
	4 A.M.	...	...	...	...	ENE	...	Fresh breeze and overcast sky. Lightning to W and SW.
	8 A.M.	...	...	...	...	ENE	...	Breeze freshening; squally; cloudy to westward.
	Noon	13° 5' N	64° 16' E	29° 547	78° 7	ENE	...	Moderate gale; overcast and squally. Barometer falling. Course S 81° W. Distance 206 miles.
	4 P.M.	...	...	29° 488	...	ENE	...	Moderate gale. Wind and sea increasing. Barometer falling.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. S. Sestos</i> —contd.	6 P.M.	...	...	...	...	ENE	...	Heavy squalls of wind and rain. Sea breaking right over the ship fore and aft.
	8 P.M.	...	...	...	...	ENE	...	Kept away to WSW. Ship unable to go her course through the terrible sea. Fresh gale with heavy squalls.
	Mid- night.	...	...	...	...	ENE	...	Strong gale with violent hail squalls.
<i>S. S. Sieve More</i>	1 A.M.	...	...	...	...	SW	...	
	4 A.M.	...	...	...	...	...	...	Fresh breeze and squally weather.
	8 A.M.	...	...	...	...	...	...	Fresh gale with heavy sea. Shipping great quantities of water.
	Noon	11° 50' N	66° 20' E	29.720	...	SW	...	Confused sea from NW and WSW. Course N 27° E. Distance 208 miles.
	4 P.M.	...	...	...	...	...	...	Moderate breeze and cloudy weather. Heavy cross sea. Ship rolling heavily, filling decks with heavy seas.
	8 A.M.	...	...	...	...	...	...	Wind increasing with squalls.
	Mid- night.	...	...	...	...	...	...	Moderate breeze and squally.
	4 A.M.	...	...	29.589	...	SW	4	
<i>S. S. Tebe</i>	Noon	14° 39' N	53° 16' E	...	...	SW	3	
	2 P.M.	...	...	29.599	...	SW	2	
	8 P.M.	...	...	29.604	...	SW	4	
	Mid- night.	...	...	...	...	SW	4	
	1 A.M.	...	...	...	...	SW	...	Light breeze and fine weather. Ship rolling heavily to a SW swell.
<i>S. S. Wheatfield</i>	7 A.M.	...	...	...	...	WSW	...	
	Noon	16° 4' N	57° 54' E	29.582	...	...	...	Moderate breeze and threatening weather. Sky overcast with much thunder and lightning to E. Heavy increasing irregular sea. Course ENE.
	8 P.M.	...	...	...	...	...	...	Strong wind and cloudy weather with heavy sea.
<i>S. S. Wistow Hall</i>	1 A.M.	...	...	...	...	SE	...	Light airs. Hazy horizon.
	3 A.M.	...	...	...	...	SSE	...	Light breeze and clear sky.
	Noon	12° 48' N	48° 35' E	29.781	88.2	...	...	Light breeze and fine weather. Course N 85° E. Distance 266 miles.
	1 P.M.	...	...	...	...	E	...	
	3 P.M.	...	...	...	...	WSW	...	Moderate breeze and clear sky.
	5 P.M.	...	...	...	...	SW	...	8 P.M. Light airs and hazy.
	Mid- night.	...	...	...	...	...	...	Light airs and cloudy weather.
<i>S. S. Zambesi</i>	4 A.M.	...	...	29.786	83.8	WNW	...	Moderate wind and sea. Fine weather.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermometer.	Wind.		REMARKS.
						Direction.	Force.	
<i>S. S. Zambesi</i> —contd.	8 A.M.	...	...	29'800	85'8	...	...	Less wind and sea.
	Noon	8° 10' N	76° 51' E	...	...	NW	...	Course N 56° W. Light wind and fine weather. NW swell. Moderate breeze.
	4 P.M.	...	...	29'768	86'8	NW	...	
	8 P.M.	...	...	29'797	86'8			
	Mid-night.	...	...	29'771	85'3	...	...	Light breeze and fine weather.

The chart for the day, Plate XXX, represents the barometer and wind observations at noon, and the general weather conditions of the whole day. It shows a very great intensification of the cyclonic depression during the preceding twenty-four hours, and a shifting of the centre towards the north-west to about Lat. 16° 40' N, and Long. 66° 14' E. The pressure in the centre had now gone down much below 28'0", and the diameter of the isobar of 29'5" had increased from about 150 miles to about 300 miles. Two hours after noon, the *Inchulva* was in the centre of the cyclone, where a pressure of 27'15" was recorded. This is 2'69 inches below the normal. This value was obtained from the indications of a large new aneroid barometer which was found to have no error when compared with a standard barometer in Bombay. In the centre of the cyclone the pointer of the aneroid went down to the reading 27'45", where it was stopped by the stem of an attached thermometer. The actual pressure having been lower than this, the fine steel pointer was bent like a spring, and it was estimated by the commander of the vessel that a tangent line drawn through the centre of the pointer along the inner straight portion and produced as far as the scale, would have cut the scale at 27'3". The vacuum box must therefore have been exerting a pressure on the pointer, equivalent to the difference between 27'3" and 27'45", viz., to '15 of an inch at least, and this quantity deducted from 27'3" gives the reading 27'15", which has been adopted as the reading in the centre of the cyclone. To the south-west of the storm field the pressure had risen considerably, the isobar of 30'0 having advanced northward about 2½°, that of 29'9 about 2°, and that of 29'8 about 1°, while that of 29'7 remained nearly stationary. Along the west coast of India the pressure had changed very slightly, a very trifling rise having occurred to the southward of Bombay, and an equally small fall to the northward. At Aden also the pressure had changed very little. The changes of pressure in the storm field and to the south-west of it largely increased the barometric gradients, and accordingly, the force of the winds was very greatly strengthened. All the vessels within a distance of 160 miles from the centre of the cyclone, of which there were six, reported a force of 9 or more. The *Inchulva* which, at noon, was about 30 miles to the north-west of the centre, had a strong gale from N at 8 A.M. At 10 A.M., the wind veered to NE, where it remained steady until noon, blowing with terrific violence and carrying everything before it. At 2 P.M., it fell, somewhat suddenly, to a calm, which lasted about 40 minutes. Shortly before 3 P.M., the wind began to blow from SW, lightly at first, but increasing in a few minutes to greater violence than before, and remaining at SW until 5 P.M., when it backed to SSW, and at 10 P.M. to S. The veering of the wind from N to NE

through four points of the compass, with the approach of the centre, and the backing from SW to S, also through four points, as the centre receded from the vessel, are somewhat inconsistent with the supposition that the ship passed in a straight line through the whole of the storm field from NE to SW. During this time the vessel was "hove to," and the storm centre was travelling in a north-westerly direction at the rate of about 7·2 miles per hour. In the 14 hours from 8 A.M. to 10 P.M., it would therefore travel about 101 miles, and as the ship passed through the centre about the middle of the period of 14 hours, she would be about 50 miles on one side of the centre at the commencement of the period, and about the same distance on the other side at the end. Yet within these short distances the wind shifted four points on each side of the centre. It will be seen from what follows, that, even at a distance of 150 miles from the centre, the wind, in a fully developed cyclone, may be much more nearly tangential than radial, and that on the average, in the cyclone now under consideration, it turned inwards only about two points, that is to say, it made an angle with the radius of about six points. Near the centre, the wind was tangential, making an angle of eight points with the radius. A vessel passing straight through the centre of such a cyclone would therefore observe a veering of the wind through only two points between the outside and the centre, a sudden shift of sixteen points at the centre, and a backing of two points between the centre and the opposite side. The only way to explain the great amount of veering and backing observed on the *Inchulva*, when within 50 miles of the centre, seems to be, to suppose that the vessel entered the more violent central portion of the cyclone on the west side; that she made some little headway against the wind, which was there blowing from N; that this northward motion, combined with the north-west movement of the storm, brought the vessel to the north-west side of the centre, where the wind was NE; that the storm centre then passed over her, leaving her on the south-east side with the wind from SW; and that she was then carried round to the east side, where the wind was from S. The log of this vessel is so important that the whole of the information for the 29th May is transcribed below:—

SUNDAY, MAY 29TH, 1881.

"Begins with dull cloudy weather. Wind light but increasing from the north. Thunder and lightning at intervals. 4 to 6 A.M.—Very heavy blinding rain. 6 A.M.—Took in the fore and aft sail, weather looking dirty, and sun rising red and fiery. We haul up the north and go half speed. 9 A.M.—We have the first indication of a cyclone advancing. All hands are called. We make the ship as snug as possible, secure everything ready for violent weather. At 10 A.M., it blows hard and shifts to the NE. Barometer falls fast. 11 A.M., the cyclone bursts over us, blowing with terrific violence. It carries everything before it. We consider ourselves in the NW quadrant with the centre coming up from SE so fast there is no time to dodge it. So we prepare for this dreaded centre to pass over us. The wind increases much as it advances. The sea cannot rise. We notice the most from the E and SE. Noon, a terrific wind still at NE, steady. Away goes fore gaff and fore trysail, hatches, in fact, everything the wind can reach blows to atoms. 2 P.M., the centre passes over us. During this time it is calm with a fearful boiling sea. The clouds hang heavy to the SW. Sun's limb clearly visible through thin yellowish haze; also several stars, at least a dozen. 2-40 P.M.—

wind light from SW; in a few minutes the cyclone has increased in force to a greater extent than that part of the storm at NE; rain falls in torrents. The howling of the wind, the drift, the howling noise destroy every other sound. Awnings, all snugly furled, blow to atoms; boat covers, ridge poles, stanchions, gangway, every thing is swept clean away. At 3-20 P.M. it blows the hardest from SW, and SSW; but veering to the S. The rain falls in torrents. The drift is so dense that we can see no more than 10 feet. We are not able to move. The hatches, all well secured, blow off; locking bars and tarpaulins go to pieces. At 4 P.M. the wind ceases a little. During the time the centre was passing over us, the barometer fell until the hand came against the tube of the thermometer, so could fall no more. We see many land birds and butterflies and whales in the centre. We employ ourselves during the calm interval clearing up the wreck and getting on hatches. As soon as the wind goes to SW, the barometer rises and continues so to do as the centre passes away from us. On the advancing half we laid in the port tack, engines going dead slow, or stopped. On the receding half we go in starboard tack, engines going the same. But the great violence of wind and a cross sea pay her head off to the port tack again, and in this position we are obliged to remain. 10 P.M.—wind S, blowing very hard. 11 P.M.—wind S, with *very heavy* squalls and rain. Though there is a decided improvement in the weather, barometer stands steady at 29'020, and during this time the squalls are most violent; the atmosphere loaded with flash lightning. Midnight—Barometer 29'100; weather improves; a tremendous sea from all directions rolls up. Crew engaged bailing out the stoke hole. Passengers were all put into No. 4 hold and their wants attended to."

The *Africa* which at noon was about 90 miles to the south-west of the storm centre, reported a gradual rise of the barometer from 29'26" at 3 A.M. to 29'51" at 4 P.M. with a gradual decrease of the strength of the wind and less lightning, thunder, and rain. At noon the sea was recorded as "mountainous from SW."

The *Mistley Hall*, about 100 miles to the south of the centre, reported a fall of the barometer from 29'55" at 1 A.M. to 29'31" at noon, with a freshening gale from WNW, and a terrific gale with fearful sea from 9 A.M. to noon, the wind backing gradually to WSW at noon, and to SW at 6 P.M., when it began to moderate, leaving the sea high and confused. The *Clan Alpine*, which at noon was about 150 miles to the north-east of the centre, after having passed through the northern half of the storm field, reported a gradual rise of the barometer from 29'36" at 4 A.M. to 29'69" at midnight, and a heavy gale veering gradually from ENE at 1 A.M. to SE at noon, with furious squalls and a high southerly sea. After noon the gale began to moderate and by 8 P.M. it had fallen to a strong breeze with fine clear weather. Here again the sea is reported to have come from several points to the right of the wind direction. The *Rohilla* which, at noon, was about 150 miles to the west of the centre, furnishes a very complete and instructive log. The barometer fell from 29'65" at 4 A.M. to 29'19" at 3'30 P.M., and rose to 29'61" at midnight. At noon the wind blew with the force of a strong gale from WNW, with heavy squalls of wind and rain, and a high confused sea from the northward, which is again several points to the right of the wind. By 1 P.M. the wind had veered to NW and by 2 P.M. it had increased to force 10 of Beaufort's scale. At 3 P.M. it backed to W and increased to force 11. The course of the ship, which up to 3'30 P.M. had been N 76° E, was then changed to ESE, and the barometer immediately began to rise. The wind then

gradually backed until, at 6 P.M., it was from SW, where it remained for the rest of the day. The greatest force, 12, was observed at 5 P.M. when the direction was WSW, after which the force gradually fell to 8 at 10 P.M., when the proper course of the ship was resumed. From 4 P.M. to 6 P.M., terrific gusts of wind and a very high confused sea were recorded, and later in the day, violent squalls with heavy rain. The *Mercedes*, which was homeward bound, also furnishes very complete information for this day. At noon she was about 150 miles to the north-west of the centre in front of the advancing storm. Her barometer fell from 29.47" at noon to 29.27", the lowest recorded, at 8 P.M. The wind gradually backed from ENE, force 8, at 1 A.M., round by N force 11, at 5 P.M., to NW by N, force 12, at midnight. When the barometer was lowest at 8 P.M., the wind was from N by W, force 12. A confused sea with heavy squalls of wind and rain was reported at 6 A.M. The rain was so heavy that it was impossible, at times, to see more than a few yards ahead of the ship. From 6 P.M. to midnight the wind blew with hurricane force, raising a terrific sea which seriously damaged the vessel. The *Sestos* was also on the north-west side of the cyclone at noon on the 29th, about 170 miles from the centre. This vessel reports the wind to have been steady from ENE throughout the day, which appears to be somewhat doubtful. Probably the direction was observed very roughly, or some evidence of a change would have been noticed, as on the *Mercedes*. The force of the wind gradually rose from a fresh breeze at 4 A.M. to a strong gale at midnight, with violent hail and rain squalls, and a terrible sea, through which the vessel was unable to keep her course. This observation of hail is very important, as it affords information relating to the vertical thickness of the cyclone—a subject which will be discussed hereafter. The *Bessie Morris* was at noon about 370 miles to the west-south-west of the centre, steaming in a direct line towards it. She reported a fall of the barometer from 29.83" at 1 A.M. to 29.52" at midnight, and a gale from WSW the force of which gradually increased, from 6 at noon to 9 at midnight, with a high sea, rain, and very heavy squalls. At noon the *Deva Gangadur* was about 220 miles to the south-south-west of the centre, and still within the influence of the cyclone, although she reported that the gale and the squalls were moderating; even at midnight the weather was still squally with heavy showers of rain. Only one observation of the wind direction is recorded, *viz.*, SW at 2 P.M. Probably the wind remained steady at SW throughout the day. The *Berengaria*, which at noon was about 240 miles to the east of the centre, reported a fast rising barometer and moderate weather with the wind from SE.

Outside the storm area, that is to say, outside the isobar of 29.7", and to the south-west, the winds were south-westerly, blowing with an average force of 5.6, as determined from the observations of nine vessels. This is .4 greater than on the previous day, proving that the south-west monsoon wind was increasing in strength at the same time that the cyclone was increasing in violence. To the north and north-east of Socotra, the winds were also south-westerly with an average force of 4.8, as determined from the observations of five vessels. On the previous day the observations of four vessels in the same part of the sea, give an average force of 3.2, also from SW. Hence it may be inferred that on the 29th, the south-westerly winds had advanced over that part of the sea much farther northward than on the 28th.

On the west coast of India, the winds were southerly from Mangalore to Bombay, and stronger than on the 28th. On the coast of Kathiawar also the winds were beginning to be influenced by the cyclone. The *Punjab* off the mouth of the Gulf of Cutch, reported a

light wind at noon from E gradually veering to S and increasing to force 5 in the afternoon, as she travelled south-eastward; while the *Euphrates*, which was off the coast of Kathiawar, also going south-east, reported a fresh SE breeze veering to S in the afternoon. These two vessels were fully 400 miles from the centre of the cyclone, and yet the winds observed by them and at Bombay, about 450 miles away, were very decidedly influenced by it.

As on the 28th, the rainfall was for the most part concentrated in the storm field, though not exclusively confined to it, light rain having fallen along the west coast from Cochin to Karwar and over the sea about 700 miles to the south-west of the storm centre. The sea was rough, as on the previous day, from Mangalore to Bombay.

1881, May 30.—The information for this day is contained in the two following tables and in the chart for noon of the same date, Plate XXXI.

TABLE XXI.—10 A.M. 30th May 1881.

STATION.	Barometer.	Change in 24 hours.	Abnormal.	Wind.		Thermometer.	Relative Humidity.	Cloud.	Rainfall.	Remarks on the weather at 10 A.M.
				Direction.	Velocity, mean of day.					
	"	"	"		Miles per hour.	°	Per cent.	0 to 10	"	
Zanzibar . . .	30.080	—0.024	+0.001	SW	5	77.7	83	4	...	
Aden . . .	29.750	+0.010	—0.070	SW	8	88.2	81	...	...	
Bushire . . .	.664	—0.079	—0.022	NW	17	84.8	54	...	...	
Karachi . . .	.732	—0.005	+0.051	S	10	90.0	65	0	...	
Bhuj . . .	.719	—0.020	+0.035	S	13	92.2	43	0	0.00	
Rajkot . . .	.738	—0.012	+0.024	S	13	91.2	48	9	0.10	
Surat . . .	.785	—0.005	+0.019	S	15	91.5	51	5	...	
Bombay . . .	.802	+0.002	—0.003	SSE	24	86.5	74	6	0.20	Sea rough.
Ratnagiri . . .	.849	+0.022	+0.048	SSE	...	86.5	64	5	0.48	
Karwar . . .	.869	+0.014	+0.028	SW	...	84.1	74	5	0.70	Fresh wind.
Mangalore . . .	.893	+0.002	+0.040	Calm	3	87.4	64	7	0.44	
Calicut . . .	.912	?	+0.031	WNW	6	81.7	82	3	0.11	Sea rough.
Cochin . . .	.913	—0.001	—0.023	NNW	1	81.0	91	10	0.38	
Colombo . . .	.886	—0.009	—0.002	SW	9	84.5	74	7	...	
Galle . . .	.874	—0.019	—0.004	NW	9	83.0	91	2	0.02	

TABLE XXII.—30th May 1881.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermometer.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. Africa</i> . . .	6 A.M.	...	...	29.639	...	...	...	
	Noon	15° 44' N	67° 40' E	...	...	...	...	
	Midnight.	...	...	...	...	...	...	Strong breeze and cloudy weather.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermometer.	WIND.		REMARKS.
						Direction.	Force.	
<i>S.S. Arabia</i>	Noon	At Jask	...	29'733	87'7	...	...	Light wind and fine weather.
	1 P.M.	Jask to Muscat	...	...	...	SSE	2	Moderate wind and sea with long SE swell and fine weather.
	4 P.M.	...	...	29'690	88'7	SSE	2	Ditto ditto.
	8 P.M.	...	...	29'773	87'7	SSE	2	Moderate wind with heavy swell.
	Midnight.	...	...	29'756	86'7	SE	2	Moderate wind with passing clouds and hazy horizon.
<i>S. Berengaria</i>	Noon	17° 43' N	72° 49' E	29'650	...	SE	...	Fine weather. Moderate breeze. Course N 73° E. Distance 152 miles.
<i>S.S. Besie Morris</i>	1 A.M.	...	...	29'524	81'5	WSW	10	Gale with terrific squalls of wind, much lightning and a perfect deluge of rain.
	7 A.M.	...	...	29'621	...	WSW	9	Heavy sea.
	10 A.M.	...	...	29'671	...	WSW	8	
	Noon	15° 50' N	65° 16' E	29'715	84'5	WSW	7	Wind moderating and sea going down. Course N 81° E. Distance 261 miles. Gale moderating.
	1 P.M.	...	...	29'721	...	WSW	7	
	5 P.M.	...	...	...	...	SW	6	
	9 P.M.	...	...	...	...	SW by S	6	
	Midnight.	...	...	29'771	...	SW by S	6	
	Noon	8° 58' N	61° 17' E	...	...	SW	...	Strong breeze and fine weather. Course N 42° E. Fine clear weather.
	Midnight.	...	...	...	...	SW	...	Cloudy with drizzling rain.
<i>S. British Crown</i>	4 A.M.	...	...	...	...	WSW	...	Heavy sea. Decks constantly flooded with water.
	10 A.M.	...	...	...	...	SW	...	
	Noon	12° 53' N	66° 22' E	...	...	...	...	
	2 P.M.	...	...	...	...	SW	...	Squally strong breeze.
<i>S. Choice</i>	8 P.M.	...	...	...	...	SW by W	...	Moderate breeze. Sky partly clouded.
	6 A.M.	...	...	...	...	SW	...	Heavy squall.
	Noon	8° 42' N	60° 25' E	29'965	...	SW	...	Course N 53° E.
	1 P.M.	...	...	...	...	SW	...	Strong breeze and squally.
<i>S.S. Clan Alpine</i>	7 P.M. to Midnight.	...	...	...	...	SW	...	Strong steady breeze and fine weather.
	1 A.M.	...	...	29'792	85'2	SE	...	Moderate breeze and fine clear weather.
	4 A.M.	...	...	...	...	E	...	Wind falling light.
	6 A.M.	...	...	...	...	SE	...	Fresh breeze and clear weather.
	Noon	19° 6' N	71° 23' E	...	...	SSE	...	Fresh breeze and high sea.
<i>S.S. Clandon</i>	1 P.M.	...	...	29'747	...	...	...	
	1 A.M.	...	...	...	...	W	...	Strong breeze and heavy sea.
	6 A.M.	...	...	...	...	...	...	Very cloudy; ship rolling heavily and straining much.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	Wind.		REMARKS.
						Direction.	Force.	
<i>S. S. Clandon</i> — contd.	Noon	25° 19' N	58° 50' E	...	...	...	...	
	4 P.M.	...	...	...	...	...	...	Increasing wind and pass- ing showers.
	Mid- night.	...	...	...	...	...	...	Strong gale.
<i>S. Deva Gangadur</i>	Noon	15° 14' N	69° 2' E	29° 595	...	SW	...	Squally with showers of rain. Course N. Distance 106 miles.
	2 P.M.	...	...	...	...	...	...	Squally with showers of rain.
<i>S. S. Eschol</i> .	Noon	15° 28' N	58° 4' E	29° 502	...	SW	...	Heavy swell with light breeze; weather hot and sultry.
	2 P.M.	...	...	...	...	WSW	...	
	4 P.M.	...	...	29° 202	...	...	...	Breeze freshening with a very heavy swell.
	8 P.M.	...	...	...	...	SW	...	
	Mid- night.	...	...	...	...	...	...	Fresh gale with a high sea.
<i>S. S. Euphrates</i> .	4 A.M.	...	...	29° 785	83° 1	S	...	Strong breeze with a heavy SW swell.
	8 A.M.	...	...	29° 865	83° 1	S	...	Moderate breeze with a heavy SW swell.
	Noon	19° 21' N	72° 24' E	29° 845	81° 1	S	...	Fresh breeze and clear weather with a heavy SW swell. Course S 30° E. Distance 145 miles.
	4 P.M.	...	...	29° 815	85° 1	S	...	Moderate breeze and clear weather with a heavy swell; ship rolling heavily.
	8 P.M.	...	...	29° 865	80° 4	S	...	
	Mid- night.	...	...	...	...	S	...	Moderate breeze and cloudy weather.
<i>S. Exporter</i> .	Noon	11° 58' N	65° 39' E	...	...	SW	...	Fresh wind and squally weather.
<i>S. Hindustan</i>	4 A.M.	...	...	...	...	...	...	Strong breeze and fair weather.
	8 A.M.	...	...	...	...	SW	...	Steady monsoon and fine weather.
	Noon	9° 41' N	63° 0' E	...	...	...	...	Strong breeze and clear weather. Course N 47° E. Distance 199 miles.
	1 P.M.	...	...	...	...	SW	...	Strong monsoon with high SW sea.
	8 P.M. to Mid- night.	...	...	...	...	...	...	Very steady monsoon throughout.
<i>S. S. Inchulva</i>	1 A.M.	...	...	...	...	S	...	Weather moderating slow- ly.
	2 A.M.	...	...	...	...	S by E	...	Barometer rising.
	3 A.M.	...	...	...	...	...	...	Sea very heavy indeed.
	4 A.M.	...	...	...	...	S to S by E	...	Wind much less.
	5-30 A.M.	...	...	...	...	...	...	Kept ship away on course NE by E.
	10 A.M.	...	...	29° 50	81° 7	...	...	Barometer steady.
	1 P.M.	...	...	...	...	SSE	...	
	6 P.M.	...	...	...	...	SSW	...	Strong wind with heavy SW sea; engines going slowly.
	8 P.M.	...	...	...	...	...	...	Moderate weather; sky clearing up.
	11 P.M.	...	...	29° 70	...	...	...	Ditto ditto.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermometer.	Wind.		REMARKS.
						Direction.	Force.	
<i>S. Iris</i>	1 A.M.	...	...	"	"	SW by W	...	Strong breeze; heavy squall with rain at 3-30 A.M.
	6 A.M.	...	...	...	...	...	...	Several squalls.
	Noon	12° 55' N	66° 9' E	29.727	...	SW	...	Strong wind and heavy squalls; heavy sea. Course N 34° E. Distance 212 miles.
<i>S. S. John Pender</i>	Mid-night.	...	...	...	...	SSW	...	Moderate breeze and clear weather with heavy swell.
	1 A.M.	...	...	29.42	82	NW by W	...	Strong gale with violent squalls of wind and rain; vivid lightning to north and west; heavy confused sea.
	4 A.M.	...	...	...	...	NW	...	Strong gale with heavy squalls of wind and rain; very high sea.
	8 A.M.	...	...	29.42	81	...	...	Gale increasing with tremendous sea and violent squalls.
	Noon	18° 3' N	61° 46' E	29.42	83	WNW	...	Hard gale with a very high sea.
	1 P.M.	...	...	...	...	W by S	...	Strong gale with violent squalls.
	4 P.M.	...	...	29.38	81	W	...	Gale increasing.
	6.30 P.M.	...	...	...	...	...	...	Very severe gale with terrific squalls of wind and rain, and tremendous sea.
<i>S. S. Mercedes</i>	8 P.M.	...	...	29.30	82	...	...	Gale still increasing, weather very dirty; tremendous sea; barometer still going down.
	Mid-night.	...	...	29.20	81	...	...	Terrible gale and tremendous sea.
	1 A.M.	...	...	...	...	NW	12	Hurricane of wind and a mountainous confused sea; ship has a strong list to port and is almost unmanageable.
	2 A.M.	...	...	29.382	...	NW	12	Sea very confused. Ship labouring heavily.
	4 A.M.	...	...	...	...	WNW	12	Wind less violent but heavy squalls of rain. Sea less confused.
	6 A.M.	...	...	...	...	W	12	Ship almost unmanageable.
	8 A.M.	...	...	29.302	...	WSW	12	Wind and sea as before; violent squalls of wind and rain.
	10 A.M.	...	...	...	...	SW	11	Wind more steady and sea less confused. Heavy mountainous sea, and ship with fearful list to port. Port rail continually under water.
	Noon	15° 30' N	64° 3' E	29.422	87.1	SW	11	Ship labouring fearfully. Seems in a perilous condition. Course S ½ W. Distance 116 miles.
	4 P.M.	...	...	...	...	SW	10	Wind and sea less violent, running true.
	8 P.M.	...	...	29.482	...	SW	10	Violent gale, wind and sea terrific.
<i>S. Mistley Hall</i>	1 A.M.	...	...	...	...	SW	...	Increasing gale with heavy sea. Ship labouring and rolling heavily and shipping large quantities of water.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. Mistley Hall— contd.</i>	6 A.M.	...	...	...	...	...	...	Gale moderating.
	Noon	14° 59' N	66° 0' E	...	...	...	...	Strong breeze with heavy squalls. Squared away to the northward and eastward.
<i>S. S. Nyanza</i>	3 A.M.	...	...	30°003	75°3	S	4 to 5	Moderate to fresh breeze with passing clouds.
	7 A.M.	...	...	29°995	78°3	S	4 to 5	Fresh breeze and cloudy weather.
	Noon	5° 11' N	54° 13' E	30°072	83°3	S	4 to 5	Fresh breeze with passing clouds. Ship rolling heavily. Course N 54½° E. Distance 268 miles.
	3 P.M.	...	...	29°980	80°3	S	4 to 5	
	4 P.M.	...	...	...	...	S	4 to 5	Wind unsteady and squally with small rain.
	6 P.M.	...	...	...	...	SE to SW	3 to 6	
	8 P.M.	...	...	29°988	77°3	S	4 to 5	
	Mid- night.	...	...	30°003	75°3	...	...	Fresh breeze and cloudy weather. Ship rolling heavily to SW swell.
<i>S. S. Punjab</i>	4 A.M.	Karachi to Bombay		29°755	72°6	SE	6	Strong wind and fine weather. Heavy sea from SW.
	8 A.M.	...	...	29°775	77°6	SSE	6	Ditto ditto.
	Noon	20° 17' N	70° 50' E	29°775	77°6	SSW	6	Strong wind and fine weather. Heavy sea from SW. Course S 48° E. Distance 184 miles.
	4 P.M.	...	...	29°775	76°6	SW	6	Weather as at noon.
	8 P.M.	...	...	29°755	78°6	SW	6 to 7	Strong breeze and squally, with cloudy weather. High sea. Ship rolling heavily.
	Mid- night.	...	...	29°775	74°6	SW	5	Fine breeze and heavy SW swell.
<i>S. Queen's Cliff</i>	Noon	...	...	...	...	SW	...	Fresh gale. Course N 45° E. Distance 208 miles.
	2 P.M.	...	...	...	...	SW	...	Fresh gale with passing squalls and showers.
<i>S. S. Rohilla</i>	4 A.M.	...	...	29°606	80°0	...	...	Moderating gale and less sea. Ship rolling heavily and taking large quantities of water over all fore and aft, at times.
	5 A.M.	...	...	...	...	...	...	Overcast with rain.
	8 A.M.	...	...	29°698	83°0	...	...	Moderate gale and heavy sea. Ship rolling heavily and taking water over fore and aft.
	Noon	17° 0' N	68° 44' E	29°702	85°0	...	...	Fresh breeze and overcast sky.
	4 P.M.	...	...	29°720	86°0	...	...	Moderate breeze and overcast sky.
	8 P.M.	...	...	29°725	84°0	SSE	...	Moderate breeze and fine weather with passing clouds.
	Mid- night.	...	...	29°752	85°0	...	...	Ditto ditto.
	1 A.M.	...	...	...	...	NE	...	Heavy gale.
<i>S. S. Sestos</i>	2 A.M.	...	...	29°424	...	N	...	Terrible and increasing gale with terrific and blinding squalls of rain.
	3 A.M.	...	...	...	...	NW	...	

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. S. Sestos</i> —contd.	4 A.M.	...	...	29'394	...	W	...	Wind still backing to west-ward, kept the ship away and ran till 7-30 A.M., when straining so badly, brought her head to wind.
	5 A.M.	...	...	...	...	W	...	
	7 A.M.	...	...	...	...	SW	...	
	8 A.M.	...	...	29'444	...	SW	...	Heavy gale with violent squalls of hail and rain. A tremendous sea broke on board on the port side doing much damage.
	Noon	17° 14' N	62° 30' E	29'453	...	...	...	Very heavy gale with terrific squalls of wind and rain. Barometer falling in the squall from 29'45 to 29'39.
	6 P.M.	...	...	29'473	...	...	...	Barometer rising. Wind and weather the same.
	8 P.M.	...	...	...	...	...	...	Squalls still very violent but less wind between them.
	10 P.M.	...	...	...	...	...	...	Gale breaking, squalls very heavy. Barometer steadily and slowly rising.
<i>S. S. Sirdhana</i>	Mid- night.	...	...	29'494	...	SW	...	Strong gale, overcast, squalls less severe and frequent. Sea still running very high, and vessel straining and labouring heavily.
	4 A.M.	At Karachi		29'746	81'7	SW	...	
	8 A.M.	Karachi to Bombay		29'768	84'7	SW	...	
	Noon	24° 18' N	66° 53' E	29'773	86'7	SE	...	Light airs and very heavy SE sea. Ship pitching very heavily. Course S 6° W. Distance 40 miles.
	4 P.M.	...	...	29'745	85'7	SE	...	Moderate wind, heavy sea, ship labouring very violently.
	8 P.M.	...	...	29'738	84'7	SE	...	Ditto ditto.
	Mid- night.	...	...	29'718	84'7	SE	...	Wind and sea increasing. Ship labouring more severely.
<i>S. S. Sivee More</i>	1 A.M.	...	...	...	...	SSW	...	
	8 A.M.	...	...	...	...	...	...	Moderate breeze and heavy sea.
	Noon	14° 29' N	68° 13' E	29'770	86	SSW	...	Fine weather but tremendously heavy sea from WSW.
	8 P.M.	...	...	...	...	SSW	...	Course N 32° E. Distance 186 miles.
	11 P.M.	...	...	...	...	SW	...	Fresh breeze with heavy SW sea.
<i>S. S. Tebe</i>	4 A.M.	...	...	...	...	SW	4	
	8 A.M.	...	...	...	...	SW	4	
	Noon	15° 23' N	57° 2' E	...	...	SW	6	Strong wind and cross sea continuous for two days.
	4 P.M.	...	...	29'604	...	SW	6	
	8 P.M.	...	...	...	...	SW	6	
	Mid- night.	...	...	...	...	SW	6	

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	Wind.		REMARKS.
						Direction.	Force.	
<i>S. S. Wheatfield</i>	1 A.M.	...	...	...	...	WSW	...	Strong breeze and cloudy weather with lightning to the eastward. Heavy SW swell.
	4 A.M.	...	...	...	...	...	...	Strong increasing wind with hard squalls.
	8 A.M.	...	...	29°38'2"	...	W	...	Strong wind with squalls of rain. Lightning.
	Noon	16° 59' N	61° 48' E.	...	...	...	...	
	10 P.M.	...	...	...	...	WSW	...	
	Mid- night.	...	...	29°23'2"	...	...	...	Whole gale with very heavy squalls and high sea. Ship labouring heavily and filling the decks with water.
<i>S. S. Wistow Hall</i>	1 A.M.	...	...	...	...	SE	...	Light breeze and hazy weather.
	4 A.M.	...	...	...	...	S	...	Moderate breeze with a south swell. Ship rolling heavily and shipping water.
	Noon	13° 47' N	52° 55' E	29°78'4"	83°2	SW	...	Fresh breeze and hazy weather with increasing SW swell. Course N 77° E. Distance 258 miles.
	8 P.M.	...	...	...	...	...	...	Similar weather with a SW sea.
	Mid- night.	...	...	...	...	SSW	...	Fresh breeze and hazy horizon.

The chart, Plate XXXI, shows a still further development of the cyclone, and a rapid change of position, the diameter of the isobar of 29°5" having increased, in the previous twenty-four hours, from about 300 miles to about 370 miles, and the centre having now moved about 210 miles to the north-westward to about lat. 18° 36' N and long. 63° 45' E. No ships are known to have been very near the centre on this day. Hence the pressure there is unknown, but, as the general dimensions of the cyclone had increased, it is probable the central depression was lower than on the 29th. The lowest recorded pressure at noon is 29°42" on the *John Pender*, which was then about 130 miles from the centre. Twelve hours later, however, the same vessel reported a pressure of 29°20", which is about '63" below normal, and the *Sestos*, which at noon was about 110 miles to the south-south-west of the centre, reported a pressure of 29°39" at 4 A.M. In the south-west quarter of the Arabian sea the pressure had again risen considerably, the isobar of 30°1" having now made its appearance there for the first time since the commencement of the storm. Along the 56th meridian, in the neighbourhood of which the rise was greatest, this isobar had extended northward to about lat. 4° N, while that of 30°0" measuring on the same meridian, had moved northward to about lat. 7½° N, and that of 29°9" to about lat. 10½° N. At Aden also the pressure rose a little, but in Ceylon and along the west coast of India, to the north of Bombay, it fell slightly, while on the intermediate coast line it rose a little. The changes along the coast were, however, small and unimportant, compared with those which took place in the storm field and to the south-west of it. The winds within the storm circle appear to have been at least as violent as on the 28th, probably more so. The *Sestos* reported a heavy gale from NE at 1 A.M., and a "terrible and increasing gale"

from N with "terrific and blinding squalls of rain" at 2 A.M. The wind gradually backed to W and SW as the vessel ran before it, in front of the advancing centre, crossing the storm path, and passing from the right hand to the left hand semicircle. The lowest barometer (29'39") was observed at 4 A.M., when the wind was from W. At 8 A.M. it had risen to 29'44" and the wind was blowing a heavy gale from SW, with violent squalls of hail and rain. At noon, when the vessel was about 110 miles to the south-south-west of the storm centre, a very heavy gale was recorded with terrific squalls of wind and rain, the barometer falling in one of the squalls from 29'45" to 29'39". At midnight the barometer had risen to 29'49", but a strong gale from SW was still blowing, although the squalls were becoming less severe and less frequent. The *Mercedes* had also run before the wind, and passed from the right hand to the left hand semicircle, crossing in front of the advancing storm. She reported that from 1 A.M. to 8 A.M., the wind blew with hurricane force (12), and gradually backed from NW to WSW. At 10 A.M., it had backed to SW with force 11, at which it remained till noon, when the vessel was about 180 miles to the south of the centre. From 4 P.M. to midnight the wind was from SW blowing with force 10. Before noon a mountainous confused sea was experienced. After noon it was reported as "less violent" and "running true," but even at midnight both wind and sea were still "terrific." From 2 A.M. to midnight the barometer rose from 29'38" to 29'48". The *John Pender* was also in front of the advancing storm on this day. Her barometer fell from 29'42" at 1 A.M. to 29'20" at midnight, and the wind backed from NW at 4 A.M. to W at 4 P.M., and gradually increased in violence from a "strong gale," with violent squalls of wind and rain and a heavy confused sea at 1 A.M., to a "terrific gale" with tremendous sea at midnight. The *Wheatfield*, which at noon was about 170 miles south-west of the centre, reported a gradual increase in the strength of the wind from a strong WSW breeze at 1 A.M. to a "whole gale" from WSW at midnight, with heavy squalls and high sea, and lightning to the eastward. The *Bessie Morris* was at noon about 210 miles south-south-east of the centre. She reported a WSW gale, force 10, at 1 A.M., with terrific squalls, much lightning and "a perfect deluge of rain." As the day advanced the weather gradually improved, and at midnight the wind had gone down to a strong breeze from SW by S, with fine weather. Her barometer rose from 29'52" at 1 A.M. to 29'77" at midnight. The *Inchulwa* was also in the receding half of the storm circle on this day. At noon she was about 180 miles to the east-south-east of the centre. She also reported gradually improving weather, and a rising barometer, with a backing of the wind from S to SSE between 1 A.M. and 1 P.M., after which the wind veered to SSW as she passed out of the storm field to the eastward. The *Rohilla*, which at noon was about 300 miles to the east-south-east of the centre, also reported a gradual decrease in the strength of the wind from a "moderate gale" at 4 A.M. to a "moderate breeze" at 4 P.M., with a rise of the barometer from 29'61" to 29'72" during the same interval. Similarly, the *Mistley Hall*, which at noon was about 290 miles to the east-south-east of the centre, reported a decrease from "a gale" at 1 A.M. to a strong breeze at noon, the direction probably remaining steady at SW.

Outside the storm field proper, to the southward and beyond the isobar of 29'7", all the vessels reported the wind to be between south and south-west, the average force being 5'7 which is '1 greater than on the 29th. The winds on the north and north-east of Socotra were also south-westerly, and the average force as given by the observations of

four ships was 4'7, which is '1 less than on the previous day. On the west coast of India from Ratnagiri to Karachi the winds were southerly, and strongest in the neighbourhood of Bombay, that is, in about the same latitude as the centre of the cyclone. Farther south they were light and north-westerly. The sea continued rough along the coast from Calicut to Bombay, and probably much farther northward.

The heavy rainfall was again concentrated within the storm field. Light rain had, however, fallen along the whole of the west coast of India from Cochin to Bombay, and several vessels outside the storm area to the southward and south-westward of the centre reported passing showers.

1881, May 31.—The two following tables contain all the meteorological information that has been collected for the 31st:—

TABLE XXIII.—10 A.M., 31st May 1881.

STATION.	Barometer.	Change in 24 hours.	Abnormal.	WIND.		Thermometer.	Relative Humidity.	Cloud.	Rainfall.	Remarks on the weather at 10 A.M.
				Direction.	Velocity, mean of day, Miles per hour.					
Zanzibar . .	30'079	—'001	—'003	WSW	5	78'8	83	2	...	
Aden . .	29'728	—'022	—'089	SSW	9	88'1	78	...	...	
Bushire . .	'589	—'075	—'091	NW	15	83'8	64	...	...	
Karachi . .	'635	—'097	—'042	S	8	90'0	70	4	...	
Bhuj . .	'682	—'037	+ '002	SW	15	93'8	48	6	...	
Rajkot . .	'710	—'028	...	SW	16	94'1	41	4	...	
Surat . .	'755	—'030	—'008	W	11	93'5	52	6	...	
Bombay . .	'801	—'001	—'002	SSW	27	89'5	68	4	0'02	Sea rough.
Ratnagiri . .	'825	—'024	+ '026	SSW	...	89'6	59	6	...	
Karwar . .	'845	—'024	+ '005	SW	...	85'0	76	4	1'13	Sea rough.
Mangalore . .	'884	—'009	+ '031	Calm	2	83'9	79	7	1'11	
Calicut . .	'896	—'016	+ '015	NNW	13	80'7	86	2	0'24	Sea rough.
Cochin . .	'902	—'011	—'011	NW	3	84'0	83	8	1'00	
Colombo . .	'840	—'046	—'048	SW	13	85'5	74	8	0'12	
Galle . .	'837	—'037	—'041	WSW	10	82'0	91	7	0'05	

TABLE XXIV.—31st May 1881.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermometer.	WIND.		REMARKS.
						Direction.	Force.	
S. Africa . .	6 A.M.	...	...	29'689	...	S	...	High rolling sea from SW and clear weather. Do. do.
	Noon	16° 21' N	68° 4' E	...	...	...	...	
	Mid-night.	...	...	...	...	SW	...	Fresh breeze with passing showers and a high sea from SW.

NAME OF VESSEL	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S.S. Arabia</i>	1 A.M.	Jask to	Muscat	...	...	SE	2	Wind moderate with heavy SE swell.
	4 A.M.	...	...	29.698	85.7	SE	2	Do. do.
	8 A.M.	At	Muscat	29.736	86.7	SE	2	
	Noon	...	...	...	...	SE	2	Light breeze and fine weather.
	3 P.M.	Muscat to	Guadur	...	...	E by N	2	Thick mist. Light passing showers.
	4 P.M.	...	...	29.681	88.7	E by N	2	Heavy SE swell. Ship rolling heavily.
	7 P.M.	...	...	...	...	E by N	3	Increasing wind and sea. Every appearance of bad weather.
	8 P.M.	...	...	29.733	87.7	E by N	3	Moderate gale with a heavy SE swell. Ship rolling very violently.
	Mid- night.	...	...	29.676	86.7	E by N	4	Ship making very heavy lurches.
	1 A.M.	...	...	29.776	80.5	SW by S	6	Strong breeze and a heavy sea.
<i>S.S. Bessie Morris</i>	Noon	17° 43' N	68° 55' E	29.818	83.5	SW by S	5	Course N 65° E. Distance 234 miles.
	1 P.M.	...	...	...	82.5	SSW	4	Moderate breeze and squally.
	5 P.M.	...	...	...	...	SSW	3	
	9 P.M.	...	...	...	...	SW	2	
	Mid- night.	...	...	...	81.5	WSW	1	Squally with rain.
<i>S. Braidwood</i>	6 A.M.	...	...	...	...	SW	...	
	Noon	11° 44' N	63° 52' E	...	...	...	...	Course N 43° E.
	2 P.M.	...	...	...	...	SW	...	Moderate breeze and cloudy weather with passing squalls.
	8 P.M.	...	...	...	...	...	...	Squall and heavy rain.
	Mid- night.	...	...	...	...	...	...	Strong breeze and heavy swell.
<i>S.S. Brinkburn</i>	1 A.M.	...	...	...	...	SW	...	Light wind. Sea from southward.
	4 P.M.	...	...	...	...	S	...	Fresh wind. Sea increasing.
	Noon	14° 38' N	57° 20' E	...	...	SW	...	Strong wind and sea. Course E by N 1/4 N. Distance 216 miles.
	4 P.M.	...	...	...	...	...	...	Heavy squall.
	Mid- night.	...	...	...	...	...	...	Gale. High cross sea.
<i>S. British Crown</i>	4 A.M.	...	...	...	...	SSW	...	
	8 A.M.	...	...	...	...	S	...	
	Noon	14° 12' N	68° 41' E	...	...	...	...	
	2 P.M.	...	...	...	...	S	...	Moderate breeze; sky partly cloudy.
	6 P.M.	...	...	...	...	SW by S	...	
<i>S. Choice</i>	Mid- night.	...	...	...	...	...	...	Fine weather. Heavy swell.
	Noon	10° 42' N	62° 55' E	29.865	...	...	...	Course N 50° E.
	4 P.M.	...	...	...	...	SW	...	Strong steady breeze and clear sky.
	Mid- night.	...	...	...	...	...	...	Light breeze and high sea.

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NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermometer.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. S. Clandon</i>	1 A.M.	...	...	...	...	SW	...	Strong breeze and heavy sea.
	4 A.M.	...	...	...	...	SW	...	Ship rolling and straining badly.
	Noon	16° 41' N	63° 3' E	...	...	SW	...	Ship rolling and straining badly. Course E by N $\frac{1}{2}$ N. Distance 253 miles.
	4 P.M.	...	...	...	...	WSW	...	Drizzling rain and hazy weather.
	Midnight	...	...	...	...	WSW	...	Wind and sea increasing; clear weather.
<i>S. Deva Gangadur</i>	Noon	16° 44' N	70° 1' E	29.695	...	...	...	Course N 61° E. Distance 180 miles.
	2 P.M.	...	...	...	...	S	...	Fresh breeze and cloudy weather.
<i>S. S. Eschol</i>	Midnight	...	...	...	...	...	...	Moderate baffling winds, with showers of rain.
	8 A.M.	...	...	...	...	...	...	Heavy gale and a high sea.
	9 A.M.	...	...	...	...	SW	...	Wind moderating a little, but sea tremendously high.
<i>S. S. Exporter</i>	Noon	16° 15' N	61° 50' E	...	...	...	...	Heavy gale and a high sea. Course E. by N. Distance 222 miles.
	1 P.M.	...	...	...	...	SW	...	Strong gale and a very heavy sea.
	Midnight	...	...	...	...	...	...	Moderate gale and a strong sea.
	Noon	13° 55' N	66° 58' E	...	...	SSW	...	Moderate breeze and cloudy weather.
<i>S. Hindustan</i>	9 P.M.	...	...	...	...	S	...	...
	8 A.M.	...	...	...	...	SW	...	Strong monsoon with bright clear weather and high sea.
	Noon	12° 14' N	65° 15' E	...	...	...	...	Ditto ditto. Course N 41° E. Distance 204 miles.
<i>S. S. Inchulloo</i>	8 P.M.	...	...	...	...	SW	...	Wind falling lighter. Overcast at midnight.
	1 A.M.	...	...	...	...	Sto SW	...	Strong wind and a very heavy SW sea.
	Noon	16° 35' N	67° 30' E	...	...	Sto SW	...	Strong wind and less sea, though heavy.
<i>S. Iris</i>	10 P.M.	...	...	29.75	...	SW	...	Strong wind.
	1 A.M.	...	...	...	...	SSW	...	Light breeze and clear weather.
	4 A.M.	...	...	...	...	...	...	Squally.
	Noon	15° 10' N	67° 23' E	29.727	...	...	...	Moderate breeze and hazy weather with heavy swell. Course N 28° E. Distance 153 miles.
	1 P.M.	...	...	...	...	S	...	...
<i>S. S. John Pender</i>	3 P.M.	...	...	...	...	SW	...	Smart breeze and heavy weather.
	Midnight	...	...	...	...	...	...	Light breeze and showery weather.
	1 A.M.	...	...	...	...	W	...	Terrific gale with very severe squalls and blinding rain. Tremendously high sea. Ship labouring very heavily. Decks continually flooded. Barometer still falling.
	4 A.M.	...	...	29.70	80	...	...	...
	6.30 A.M.	...	...	29.06	79	...	...	Complete hurricane with a frightful sea.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S.S. John Pender— contd.</i>	1 P.M.	...	...	...	...	SW	...	Wind falling more to the south and still blowing very hard; squalls less violent and less frequent. Frighful sea.
	4 P.M.	...	...	29'15	83	...	...	Wind still blowing very hard, but not quite so fierce as in the forenoon; a very high sea.
	8 P.M.	...	...	29'25	82	SW by S	...	Weather looking a little finer.
	9 P.M.	...	...	...	...	...	...	Wind blowing as hard as ever; most terrific squalls of wind and blinding rain.
	Mid- night	...	...	29'30	81	...	...	Weather very dirty. Fierce gale with a very high confused sea.
<i>S. S. Mercedes</i>	1 A.M.	...	...	...	...	SW	10	Violent gale and a very heavy sea with heavy rain & squalls.
	4 A.M.	...	...	...	...	SW	9	Wind less violent. Sea terrific.
	8 A.M.	...	...	29'582	...	SW by S	9	Wind moderating, but sea very heavy from SW.
	Noon	15° 42' N	63° 57' E	29'582	...	SW by S	9	Wind and weather unchanged; sky cloudy.
	2 P.M.	...	...	...	...	SW by S	9	Violent gale; ship labouring and straining heavily.
	8 P.M.	...	...	...	...	SW by S	9	Violent gale and heavy sea.
	Mid- night	...	...	...	...	SW by S	9	Violent gale and terrific sea.
	1 A.M.	...	...	...	...	SW by S	...	Fresh breeze and clear weather.
<i>S. Mistle Hall</i>	Noon	17° 6' N	68° 20' E	29'690	...	SSW	...	Course N 45° E. Distance 184 miles.
	...	...	...	...	...	...	...	...
<i>S.S. Nyansa</i>	3 A.M.	...	...	29'973	75'3	S	4 to 5	Fresh breeze and cloudy weather; ship rolling heavily.
	7 A.M.	...	...	29'950	80'3	SSW	4 to 5	Diitto ditto
	11 A.M.	...	...	29'924	86'3	SSW	4 to 5	Fresh breeze and cloudy weather; ship rolling heavily.
	Noon.	7° 53' N	57° 42' E	...	...	...	...	Course N 51° E.
	3 P.M.	...	...	29'910	84'3	SW	4 to 5	Fresh breeze and cloudy weather.
	7 P.M.	...	...	29'910	80'3	SW	4 to 5	Fresh breeze with fine weather and passing clouds. High confused sea.
	11 P.M.	...	...	29'908	77'3	SW	4 to 5	Ship rolling heavily to SW swell.
	Noon.	12° 13' N	65° 30' E	...	...	SW	...	Strong breeze and clear weather; course N 53° E. Distance 196 miles.
<i>S. Queen's Cliff</i>	2 P.M.	...	...	...	...	SW	...	Strong breeze and clear weather; heavy sea; ship rolling and straining heavily.
	Mid- night.	...	...	...	...	...	...	Fresh breeze and fine clear weather.
	1 A.M.	...	...	...	...	SSW to SW	...	Fresh gale; at 4 A.M. gale moderating; fine weather, but overcast; sea still very heavy.
<i>S.S. Sestos</i>	8 A.M.	...	...	...	...	...	...	Moderate gale with better weather.
	Noon.	17° 10' N	63° 15' E	29'614	78'7	SW	...	Moderate gale; weaheer clearing up.

NAME OF VESSEL.	HOUR.	Latitude.	Longitude.	Barometer.	Thermometer.	WIND.		REMARKS.
						Direction.	Force.	
<i>S.S. Sirdhana</i>	1 A.M.	...	...	"	...	S	...	Moderate wind and cloudy weather with very heavy sea; ship labouring very severely.
	4 A.M.	...	...	29'703	82'7	S	...	Compelled to haul ship's head to S.
	8 A.M.	...	...	29'728	84'7	S	...	Weather unchanged.
	Noon	21° 48' N	67° 57' E	29'745	85'7	...	...	Course S 23° E. Distance 153 miles.
	1 P.M.	...	...	...	...	SW	...	Fresh wind and squally. High SW sea; ship labouring very severely.
	4 P.M.	...	...	29'705	85'7	...	...	Same weather.
	8 P.M.	...	...	29'715	85'7	...	...	Ditto.
	Mid-night.	...	...	29'749	85'7	...	...	Ditto.
<i>S. Slieve More</i>	4 A.M.	...	...	...	...	SSE	...	Moderate breeze and clear weather.
	Noon.	16° 54' N	70° 24' E	29'800	...	SSW	...	Ditto. Course N 43° E. Distance 194 miles.
	8 P.M.	...	...	...	...	...	...	Decreasing breeze and clear weather.
<i>S.S. Tebe</i>	4 A.M.	...	...	29'525	...	SW	6	
	8 A.M.	...	...	22'465	...	SW	7	
	Noon.	16° 19' N	60° 54' E	...	...	SW	7	
	2 P.M.	...	...	...	...	...	...	Very strong wind and heavy cross sea.
	4 P.M.	...	...	29'465	...	SW	6	
	8 P.M.	...	...	29'525	...	SW	6	
	Mid-night.	...	...	...	...	SW	6	
<i>S.S. Wheatfield</i>	1 A.M.	...	...	...	...	SW by S	...	Strong wind and heavy sea with lightning and very heavy squalls of wind and rain.
	4 A.M.	...	...	...	...	...	...	Weather more moderate.
	8 A.M.	...	...	...	...	SW by S	...	Sea moderating but still very high.
	Noon.	18° 3' N	65° 30' E	29'583	...	...	...	Fresh breeze and fine weather.
	8 P.M.	...	...	...	...	S	...	Ditto ditto.
<i>S.S. Wistow Hall</i>	Mid-night.	...	...	...	...	...	...	Ditto ditto.
	1 A.M.	...	...	...	...	SW	...	Sea going down.
	Noon.	15° 14' N	57° 8' E	29'614	82'2	SW	...	Fresh breeze and hazy weather with a high sea.
	1 P.M.	...	...	...	...	WSW	...	Ditto ditto. Course N 70° E. Distance 260 miles.
	8 P.M.	...	...	...	...	...	...	Moderate gale.
	Mid-night.	...	...	...	...	...	...	Overcast sky.
								Gale increasing.

The chart for the day, Plate XXXII, exhibits the meteorological conditions at noon. It shows that the cyclonic depression had continued to expand until the isobar of 29'5 was now about 440 miles in diameter. At noon on the 30th it was about 370 miles. On the 31st the centre had moved forward to about Lat. 19° 20' N. and Long. 61° 32' E. In other words, it had travelled in the preceding twenty-four hours about 158 miles in a west-

north-west direction. The lowest pressure shown on the chart is 29'0" which has been obtained by interpolation from the log of the *John Pender*. Unfortunately, no opportunity of comparing the barometer of this vessel with a standard has presented itself, and it is therefore needful to assume that the instrument had no error. As the *John Pender* is a telegraph ship, specially employed on scientific work, it is probable that this assumption is correct. If so, the cyclone was much larger on the 31st than on any previous day, and therefore the pressure in the centre would probably be much lower than before, perhaps far below 27 inches; but, as no ship is known to have been in, or near, the centre on that day, the actual pressure there is unknown. The lowest recorded pressure is 29'06", on the *John Pender*, at 6 hours 30 min. A.M. This is 0'77" below the normal pressure for the time of the year, and for the position then occupied by the ship. To the south of the storm field the pressure appears to have fallen considerably, the isobar of 30'1 having disappeared, and those of 30'0, 29'9, and 29'8 having receded southwards about 3°, 2°, and 1° respectively, while that of 29'7 remained nearly stationary. Thus, the gradients between the storm field and the equator were greatly reduced. The pressure also fell somewhat along the whole of the west coast of India and in Ceylon, the fall being greatest in the extreme north and extreme south. It also fell a little at Aden and considerably at Bushire. As on the previous day, the winds were very violent inside the isobar of 29'5, increasing from a moderate gale (force 7) on that isobar to a complete hurricane (force 12) near the centre of the cyclone. Between the isobars of 29'5 and 29'7 the average force of the wind given by the observations of seven ships was 6'0. Outside the storm field and outside the isobar of 29'7 to the south and south-east of the centre the winds were all south-westerly, with an average force, as determined from the observations of thirteen ships, of 4'8, which is '9 less than on the 30th. This accords with the above mentioned decrease of the barometric gradients over the same area. The *John Pender* is the only vessel known to have been near the centre on this day. At 1 A.M. she experienced a terrific gale from W, with severe squalls and "blinding rain," and a tremendously high sea, with a falling barometer. At 6-30 A.M. the barometer had fallen to 29'06", and the wind had risen to a "complete hurricane," with a "frightful sea." At 1 P.M. the wind had backed to SW and the squalls had become less violent and frequent, although a "frightful sea" was still running. At 4 P.M. the barometer stood at 29'15", the wind was "still blowing very hard," although it was not quite so fierce as in the forenoon, and the sea continued very high. At 8 P.M. the barometer had risen to 29'25", but at 9 P.M. the wind was blowing as hard as ever, with most terrific squalls of wind and "blinding rain." At midnight a fierce gale, a very high confused sea, and a barometer reading of 29'30" were recorded. The *Tebe*, the *Eschol* and the *Sestos*, all on the south side of the cyclone, about 200 miles from the centre, reported gales or very strong winds before noon, and gradually improving weather, as the day advanced. The *Clandon*, the *Mercedes* and the *Wheatfield*, which were in the south-east quadrant of the cyclone, between 250 and 300 miles from the centre, reported a similar improvement in the state of the weather. On the contrary, the *Brinkburn* and the *Wistow Hall*, which at noon were about 400 miles to the south-west of the centre, steaming eastward, and therefore getting nearer to the centre, both reported a gradual increase in the strength of the wind from a fresh breeze in the early morning to a gale at midnight, with the usual high sea and squally weather. The *Arabia*, which at noon was at Muscat, about 330 miles to the NNW of the centre, and which in the afternoon was sailing thence to Guadar on the Mekran coast, reported that at 7 P.M. the wind and sea were increasing with every

appearance of bad weather. At 8 P.M. a "moderate gale" from E by N and a heavy south-east swell were recorded. In this case also, the sea came from a direction several points to the right of the wind.

About 500 miles from the centre of the cyclone, and to the south-east of it, the winds were a little more southerly than at the same distance to the south, thus showing the tendency of the cyclone to draw the air towards the centre, even from so great a distance as 500 miles. On the west coast of India the strength of the wind was now but very slightly affected by the cyclone. Only at Bombay was it unusually strong. Its direction, however, along the whole of the coast from Ratnagiri northward to Karachi, was generally more southerly than the normal direction, and it is probable that this deflection was due to the influence of the cyclone. From Karwar southward the winds were of the normal type. The distribution of the rainfall shown by the chart indicates no concentration of rain in the storm field, but this is doubtless because very few ships happened to be near the centre on this day. The log of the *John Pender* suffices to show that very heavy rain fell near the centre, for twice during the day the entry "blinding rain" appears. No other vessel was near the centre, and no other recorded unusually heavy rain. There was, however, general and moderate rain to the south and south-east of the centre, and along the west coast of India from Cochin to Karwar. Along the whole of the coast from Calicut to Bombay the sea continued rough.

1881, June 1st.—The meteorological information for this day is contained in the following tables:—

TABLE XXV.—10 a.m., 1st June 1881.

STATION.	Barometer.	Change in 24 hours.	Abnormal.	WIND.		Thermometer.	Relative Humidity.	Cloud.	Rainfall.	Remarks on the weather at 10 A.M.
				Direction.	Velocity mean of day.					
	"	"	"		Miles per hour.	°	Per cent.	0 to 10	"	
Zanzibar . .	30.063	—0.11	—0.17	SW	5	77.7	84	4	0.09	
Aden . .	29.686	—0.42	—1.28	S	9	88.0	74	...	...	
Bushire . .	547	—0.42	—1.27	NW	19	82.8	60	...	...	
Karachi . .	655	+0.20	—0.18	SW	15	89.0	71	2	...	
Bhuj . .	652	—0.30	—0.25	SW	17	92.6	47	5	...	
Rajkot . .	681	—0.29	—0.26	WNW	19	93.5	39	6	...	
Surat . .	735	—0.20	—0.25	W	23	91.5	57	5	...	
Bombay . .	784	—0.17	—0.16	WSW	13	88.7	75	4	0.15	Sea moderate.
Ratnagiri . .	807	—0.18	+0.09	WSW	...	86.5	83	3	0.60	p.
Karwar . .	811	—0.34	—0.28	SW	...	81.1	86	10	0.47	Sea very rough, f. d. r.
Mangalore . .	813	—0.71	—0.41	NNW	3	82.4	83	9	1.20	
Calicut . .	827	—0.69	—0.55	NNW	9	81.7	82	3	0.06	Sea rough.
Cochin . .	824	—0.78	—0.70	NW	3	84.0	83	10	0.10	
Colombo . .	814	—0.26	—0.74	SW	15	84.5	77	8	...	
Galle . .	802	—0.35	—0.76	WNW	10	82.5	91	6	0.07	

TABLE XXVI.—1st June 1881.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	Wind.		REMARKS.
						Direction.	Force.	
<i>S. Africa</i>	Noon	16° 35' N	68° 24' E	"	°			
<i>S.S. Arabia</i>	1 A.M.	Muscat to	Guadur	...	...	E	4	Strong wind and cloudy weather with heavy SE swell.
	4 A.M.	...	...	29.646	86.7	E	4	Ship labouring and rolling very violently.
	8 A.M.	...	...	29.726	86.7	E	4	Fresh gale and fine weather. Heavy SE swell, ship rolling and pitching most violently.
	Noon	...	...	29.766	86.7	E	4	Same weather with haze on horizon.
	4 P.M.	...	...	29.696	86.7	E	3	Strong breeze and hazy weather. Heavy head sea and tremendous cross swell rolling up from S. Ship labouring and rolling most violently.
	8 P.M.	...	...	29.815	86.7	E	3	Sea increasing. Ship rolling and lurching more violently than before.
	Mid- night.	...	...	29.781	84.7	E	3	Less wind but tremendous sea rolling up from S.
<i>S. Braidwood</i>	4 A.M.	...	...	...	...	SW	...	
	Noon	14° 19' N	66° 26' E	...	...	...	...	Course N 44° E.
	2 P.M.	...	...	...	...	SW	...	Strong breeze.
	Mid- night.	...	...	...	...	SE	...	Light wind.
<i>S.S. Brinkburn</i>	1 A.M.	...	...	...	...	S	...	Strong gale and heavy sea.
	Noon	16° 0' N	66° 21' E	...	...	...	...	Strong gale. Heavy sea continually filling the decks.
	2 P.M.	...	...	...	...	...	...	Course E by N $\frac{1}{2}$ N. Distance 22.5 miles.
	8 P.M.	...	...	...	...	...	...	Heavy sea burst bulwark of lower bridge and washed it away.
	Mid- night.	...	...	...	...	...	...	Moderate gale.
<i>S. British Crown</i>	6 A.M.	...	...	...	...	SW $\frac{1}{2}$ W	...	Wind and sea more moderate.
	Noon	15° 36' N	70° 12' E	...	...	...	...	
	2 P.M.	...	...	...	...	SW by W	...	Moderate breeze and fine weather.
	Mid- night.	...	...	...	...	WSW	...	Fresh breeze and partly cloudy.
<i>S. Canute</i>	4 A.M.	...	...	...	...	SE	...	Moderate breeze. Dark heavy clouds to SE.
	8 A.M.	...	...	...	...	SSE	...	
	Noon	1° 15' N	64° 10' E	30.054	...	...	...	Moderate breeze and hazy weather. Course N 30° E. Distance 131 miles.
	2 P.M.	...	...	...	...	SE	...	Moderate breeze and hazy weather.
	8 P.M.	...	...	...	...	SSE	...	Heavy showers of rain.
	Mid- night.	...	...	...	...	...	...	Moderate breeze and heavy rain.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermometer.	Wind.		REMARKS.
						Direction.	Force.	
<i>S. Choice</i>	Noon	12° 53' N	65° 9' E	29° 865	...	SW	...	Course N 48° E.
	1 P.M.	...	...	...	...	SW	...	Light wind and high sea. Ship rolling very heavily at times.
	8 P.M.	...	...	...	...	SWbyW	...	
<i>S.S. Clan Macleod</i>	1 A.M.	...	...	...	...	Calm	...	Fine clear weather and smooth sea.
	8 A.M.	...	...	...	...	S	...	Light breeze and clear weather.
	10 A.M.	...	...	...	...	SW	...	Breeze freshening and sea rising.
	Noon	13° 4' N	47° 24' E	...	...	SW	...	Fresh breeze and confused sea. Course N 80° E. Distance 205 miles.
	1 P.M.	...	...	...	...	SW	...	Fresh breeze and hazy weather. Ship rolling heavily.
	8 P.M.	...	...	...	...	W by S	...	Light breeze and fine weather.
<i>S.S. Clandon</i>	1 A.M.	...	...	...	...	SW	...	Strong breeze and clear weather.
	6 A.M.	...	...	...	...	SW	...	Squally with rain and strong sea.
	Noon	17° 52' N	66° 50' E	...	...	SW	...	Fine steady breeze and clear weather.
	8 P.M.	...	...	...	...	SW	...	Same wind and weather.
<i>S.S. Coniston</i>	Noon	6° 36' N	78° 2' E	...	...	WNW	...	Strong wind and heavy cross sea, with heavy squalls of rain.
<i>S. Deva Gangadur</i>	Noon	17° 48' N	71° 45' E	29° 695	...	...	...	Light breeze and cloudy weather. Course N 56° E. Distance 120 miles.
	2 P.M.	...	...	...	...	SW	...	Moderate breeze and passing showers of rain.
<i>S.S. Eschol</i>	1 A.M.	...	...	...	...	SW	...	Shipped a heavy sea.
	8 A.M.	...	...	...	...	SW	...	Fresh gale, but less wind and sea.
	Noon	17° 10' N	65° 25' E	...	...	...	...	Moderate gale.
	1 P.M.	...	...	...	...	SW	...	Moderate gale with a high sea.
	4 P.M.	...	...	...	...	S	...	Fresh breeze.
	8 P.M.	...	...	...	...	...	...	Moderate breeze.
	Mid-night.	...	...	...	...	...	...	Moderate breeze and a heavy swell. Fine clear weather.
<i>S. Exporter</i>	7 A.M.	...	...	...	...	SSW	...	
	Noon	15° 58' N	68° 0' E	...	...	SW	...	Moderate breeze and clear weather.
<i>S. Hindustan</i>	4 A.M.	...	...	...	...	SW	...	Fine clear weather.
	Noon	14° 23' N	67° 06' E	...	...	...	...	Course N 40° E. Distance 168 miles.
<i>S.S. Inchulva</i>	1 A.M.	...	...	...	...	SW to W	...	Light wind and fine weather. Sea much less.
	Noon	18° 31' N	70° 59' E	...	...	W	...	Light wind. Course NE by E ½ E. Distance 177 miles.
<i>S. Iris</i>	2 A.M.	...	...	...	...	SW	...	Light breeze and showers of rain.
	4 A.M.	...	...	...	...	SW	...	Light breeze and hazy weather.
	Noon	16° 32' N	69° 8' E	29° 727	...	SW	...	Light breeze and cloudy weather. Course N 51° E.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. Iris.</i> —contd.	Mid- night.	...	...	...	...	SW	...	Moderate breeze and pass- ing showers.
<i>S.S. John Pender</i>	1 A.M.	...	...	...	...	SW by W	...	Strong gale and high sea. Heavy squalls of wind and rain.
	3 A.M.	...	...	29.35	81	WSW	...	Hard gale with tremendous sea and terrific squalls of wind and rain. Ship labouring and rolling heavily. Decks complete- ly deluged with water at times.
	8 A.M.	...	...	29.46	82	...	...	
	Noon	...	...	29.50	82	...	...	Wind seems a little more moderate. Squalls less frequent and less violent.
	1 P.M.	...	...	...	...	WSW	...	Strong gale with high sea. Heavy weather.
	4 P.M.	...	...	29.45	81	SW	...	Gale more moderate, but still very high.
	8 P.M.	...	...	29.52	80	...	...	Wind and sea increasing; blowing hard; heavy squalls.
	Mid- night.	...	...	29.50	82	SSW	...	Dark and dreary.
	1 A.M.	...	...	...	...	SW by S	8	Violent gale and a heavy confused sea. Ship labouring and straining heavily. Every thing moveable washed off the decks.
<i>S.S. Mercedes</i>	Noon	15° 50' N	62° 33' E	29.422	80.1	SW by S	8	No improvement in the weather. Course N 84° W. Distance 102 miles. Decided to return to Bombay.
	8 P.M.	...	...	...	...	SW by S	8	Violent gale with a heavy sea.
	Mid- night	...	...	...	...	SW by S	8	Occasional squalls of rain.
<i>S. Mistley Hall</i>	1 A.M.	...	...	...	...	S	...	Moderate breeze and fine weather.
	8 A.M.	...	...	...	...	WSW	...	
	Noon	18° 11' N	70° 47' E	...	...	WSW	...	Course N 59° E. Distance 144 miles.
<i>S.S. Nyansa</i>	3 A.M.	...	...	29.898	77.3	SW	4 to 5	Fresh breeze and cloudy weather. Ship rolling heavily to SW swell.
	7 A.M.	...	...	29.872	87.3	SW	4 to 5	Ditto ditto.
	11 A.M.	...	...	29.879	88.3	SW	4 to 5	Ditto ditto.
	Noon	10° 22' N	61° 17' E	...	...	...	...	Course N 52° E. Distance 270 miles.
	3 P.M.	...	...	29.857	85.3	SW	5 to 6	Strong breeze and fine weather. High SW swell. Ship rolling heavily.
	7 P.M.	...	...	29.852	83.3	SW	5 to 6	Ditto ditto.
	11 P.M.	...	...	29.843	79.3	SW	4 to 5	Fresh breeze and fine wea- ther.
<i>S. Queen's Cliff</i>	Noon	14° 0' N	67° 37' E	...	...	...	...	Light breeze. Course N 49° E. Distance 164 miles.
	2 P.M.	...	...	...	...	SW	...	Light breeze and fine clear weather.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S.S. Sestos</i>	1 A.M.	...	...	...	...	SSW	...	Gale moderating. Weather clearing up.
	Noon	17° 2' N	63° 32' E	29'674	...	...	...	
<i>S.S. Sirdhana</i>	4 A.M.	...	...	29'711	83'7	SW	...	Wind and sea moderating.
	8 A.M.	...	...	29'748	84'7	SW	...	
	Noon	19° 23' N	70° 49' E	29'748	84'7	SW	...	Moderate wind and cloudy weather. Course S 48° E. Distance 216 miles. Ship rolling heavily at times.
	4 P.M.	...	...	29'745	85'7	SW	...	
	8 P.M.	...	...	29'743	86'7	SW	...	
	Mid-night	...	...	29'775	85'7	SW	...	
<i>S. Slieve More</i>	4 A.M.	...	...	...	...	SSW	...	Light breeze and heavy swell. Course N 52° E. Distance 145 miles. Moderate breeze and clear weather.
	9 A.M.	...	...	...	...	SW	...	
	Noon	18° 20' N	72° 24' E	29'820	...	W	...	
	4 P.M.	...	...	...	...	W	...	
<i>S.S. Tebe</i>	4 A.M.	...	...	...	...	SSW	4	Vessel rolling heavily.
	8 A.M.	...	...	29'554	...	SSW	4	
	Noon	16° 47' N	64° 24' E	29'574	...	SSW	4	
	4 P.M.	...	...	29'594	...	SSW	4	
	8 P.M.	...	...	29'633	...	SSW	2	
	Mid-night	...	...	29'743	...	SSW	2	
<i>S.S. Tenasserim</i>	4 A.M.	...	...	29'655	84'7	SW by W	4 to 5	Course N 54° W. Distance 186 miles. Heavy SW swell.
	8 A.M.	...	...	29'702	83'7	SW	4	
	Noon	20° 43' N	69° 52' E	29'699	84'7	SW	3 to 4	
	4 P.M.	...	...	29'642	85'7	SW	4 to 5	
	8 P.M.	...	...	29'635	84'7	SW	5	
	Mid-night	...	...	29'667	83'7	SW	3 to 4	
<i>S.S. Wheatfield</i>	1 A.M.	...	...	...	...	S	...	Fresh breeze and fine weather. Fresh breeze and cloudy weather; light rain. Fresh breeze and fine weather. Course E by N. Light breeze and fine weather with SW swell. Fresh gale and a high sea.
	7 A.M.	...	...	...	...	...	...	
	Noon	18° 23' N	68° 57' E	...	...	...	...	
	Mid-night	...	...	...	...	...	...	
<i>S.S. Wistow Hall</i>	1 A.M.	...	...	...	...	WSW	...	Hurricane and tremendous high sea. A perfect hurricane. Two boats carried away. Brought ship's head to wind and sea, and eased engines. Ship pitching tremendously and shipping heavy seas, doing much damage.
	4 A.M.	...	...	...	...	SW	...	
	4-30 A.M.	...	...	...	...	SW	...	
	6 A.M.	...	...	...	...	SW	...	
	9 A.M.	...	...	...	...	SW	...	
	Noon	16° 52' N	60° 8' E	...	...	SW	...	

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. S. Wistow Hall</i> — contd.	3 P.M.	...	...	...	...	SW	...	Wind changed to moderate. Kept ship away before the wind.
	4 P.M.	...	...	...	...	SW	...	Strong gale and high sea.
	8 P.M.	...	...	...	...	SSW	...	Fresh breeze and overcast sky.
	11 P.M.	...	...	...	...	SSW	...	Less wind and decreasing sea with heavy showers of rain.

The meteorological conditions at noon are represented by the chart for the day, Plate XXXIII, which shows that the cyclonic depression of the barometer had now begun to fill up, the diameter of the isobar of 29·5 having contracted from about 440 miles to about 330 miles during the preceding twenty-four hours. The centre of the depression had now moved to about Lat. 19° 50' N and Long. 60° 15' E, having travelled in the course of the day about 93 miles in a west-north-west direction. The lowest pressure marked on the chart is 29·50". This was observed on the *John Pender* at noon, but at 3 A.M., the same ship reported a pressure of 29·35", which is ·48" below the normal pressure, and the lowest recorded by any vessel on the 1st of June. As the storm passed towards the north-north-west, and began to fill up, the pressure in the rear of it rapidly increased. In the south of the Arabian Sea, however, the pressure remained nearly stationary, while on the west coast of India it fell slightly, and in Ceylon more considerably. These changes of pressure produced a great decrease of the barometric gradients to the south and south-east of the storm field, and accordingly, as will presently be seen, the strength of the winds over this region rapidly decreased. At Aden and Bushire the pressure also fell somewhat, and at both stations it was now about an eighth of an inch below the normal. No vessels are known to have been very near the centre of the cyclone on this day. The *John Pender* was the nearest, and she no doubt experienced the roughest weather. At noon she was probably about 160 miles to the south-west of it. At 1 A.M., she reported a strong gale and high sea, with heavy squalls of wind and rain; at 3 A.M., a hard gale from WSW., and a tremendous sea, with terrific squalls of wind and rain and a barometer reading of 29·35". At noon, the barometer had risen to 29·50", the wind had moderated a little, and the squalls were becoming less frequent and violent. At 4 P.M., the wind backed to SW, but was still very high, and by midnight it had backed to SSW. These changes of direction show that the storm was passing to the northward of the vessel from east to west. The *Wistow Hall* was a little farther from the centre at a distance of about 200 miles due south at noon. She also reported a gradual backing of the wind from WSW to SW between 1 A.M., and 8 P.M. At 1 A.M., a fresh gale and a high sea were recorded; at 4 A.M., a hurricane and tremendous sea; at 4h, 30m. A.M. a "perfect hurricane," in which two boats were carried away. At 6 A.M., the ship's head was brought to the wind and sea, and the engines were eased. At 3 P.M., the wind moderated and the ship was "kept away before the wind." At 4 P.M., a strong gale and a high sea were recorded. At 8 P.M., it had fallen to a fresh breeze, and at 11 P.M. there was less wind and a decreasing sea with heavy showers of rain. The *Brinkburn*, still farther to the south of the centre, at a distance of about 260 miles at noon, reported a strong southerly gale with a

heavy sea from 1 A.M., to noon, falling to a moderate gale at 8 P.M., and to a more moderate wind by midnight. The *Mercedes*, which at noon was about 320 miles to the south-south-east of the centre reported a violent gale from SW by S, force 8, and a heavy confused sea, which continued all day with occasional squalls of rain. The *Sestos*, about 300 miles to the south-west of the centre, reported a moderate gale from SSW and the weather clearing up. The *Tebe*, about 50 miles farther away from the centre, and in the same direction from it, reported a gradual rise of the barometer from 29'55" at 8 A.M. to 29'74" at midnight, with the wind steady from SSW, but decreasing in force as the day advanced. And the *Eschol*, about 400 miles to the east-south-east of the centre, reported a fresh gale at 8 A.M.; a moderate gale with a high sea at 1 P.M.; a fresh breeze from S at 4 P.M., and a moderate breeze with fine clear weather and a heavy swell at midnight, showing a gradual improvement in the weather throughout the day.

Outside the isobar of 29'7" between south and east of the centre, the average force of the wind, as determined from the noon observations of thirteen ships, was 3'2, which is 1'6 lower than on the previous day. The direction of these winds was SSE near the equator; SW between lat. 10° N and 16° N, and more westerly about lat. 18° N. On the west coast of India, from Karachi to Karwar, the winds were south-westerly. To the south of Karwar they were light and north-westerly.

The heaviest rainfall was observed by those vessels nearest the centre. Most of those outside the isobar of 29'6", and between the centre and the Bombay Coast, reported fine weather, only three out of twenty-one having recorded passing showers or light rain. One vessel, the only one near the equator, reported heavy rain. Light to moderate rain fell along the west coast of India from Cochin to Bombay, but to the northward of Bombay none was recorded.

1881, June 2nd.—The two following tables contain the available information for this day:—

TABLE XXVII.—10 A.M., 2nd June 1881.

STATION.	Barometer.	Change in twenty-four hours.	Abnormal.	Wind.		Thermo- meter.	Relative humidity.	Cloud.	Rainfall.	Remarks on the weather at 10 A.M.
				Direction.	Velocity mean of day.					
	"	"	"		Miles per hour.	"	Per cent	0 to 10	"	
Zanzibar . .	30'092	+ '024	+ '004	SW	4	77'5	84	7	0'08	
Aden . .	29'734	+ '048	— '077	SSW	8	91'7	65	...	...	
Bushire . .	'593	+ '046	— '075	NW	12	89'8	47	...	...	
Karachi . .	'655	0	— '014	SW	15	90'0	73	1	...	
Bhuj . .	'660	+ '008	— '014	W	17	93'0	45	8	...	
Rajkot . .	'685	+ '004	— '018	W	18	95'5	36	4	...	
Surat . .	'752	+ '017	— '005	W	17	87'6	55	4	0'04	
Bombay . .	'784	0	— '014	W	13	89'1	69	5	0'12	Sea slight.
Ratnagiri . .	'808	+ '001	+ '012	W	...	87'5	68	5	0'35	P.
Karwar . .	'809	— '002	— '029	N	...	84'0	77	6	0'29	Sea very rough.
Mangalore . .	'849	+ '036	— '005	WNW	8	84'4	74	8	0'58	
Calicut . .	'841	+ '014	— '041	NNW	10	82'7	82	4	0'60	Ditto.
Cochin . .	'855	+ '031	— '037	NNE	3	85'0	79	10	2'20	
Colombo . .	'778	— '036	— '010	WSW	15	84'0	79	9	0'12	
Galle . .	'796	— '006	— '082	NW	12	83'0	91	7	0'17	Strong wind.

TABLE XXVIII.—2nd June 1881.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermometer.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. Africa</i>	Noon	16° 40' N	69° 36' E	...	...	W	...	Fresh breeze and passing showers of rain.
<i>S.S. Arabia</i>	1 A.M.	Muscat to Karachi		...	...	SE	3	Fresh wind with continued heavy swell from S.
	4 A.M.	...	...	29° 784	83° 7	SE	3	Ship rolling very violently.
	8 A.M.	...	...	29° 800	84° 7	SE	2	Wind decreased to a light breeze, tremendous swell from S, and thick haze on the horizon.
	Noon	...	...	29° 820	84° 7	SE	2	Light wind; with same high swell from S.
	1 P.M.	...	...	...	...	SSÉ	2	Light wind gradually veering to S with hazy weather. High swell veering round to SSW and SW.
	4 P.M.	...	...	...	...	SSE	2	Very severe rolling continues.
	8 P.M.	...	...	...	...	S	...	Clear weather with hazy horizon. Heavy swell from SW.
	Midnight	...	...	29° 798	85° 7	S	2	Light wind with heavy SW swell.
<i>S. Braidwood</i>	8 A.M.	...	...	...	...	SW	...	
	Noon	15° 32' N	67° 44' E	...	...	...	...	Course N 45° E.
<i>S.S. Brinkburn</i>	1 A.M.	...	...	...	...	SW	...	Moderate wind and sea.
	4 A.M.	...	...	...	...	...	...	Weather clearing up.
	Noon	17° 3' N	64° 15' E	...	...	...	...	Fine steady breeze. Course E by N $\frac{1}{2}$ N. Distance 220 miles.
	Midnight	...	...	...	...	...	...	Light wind and clear weather.
<i>S. British Crown</i>	6 A.M.	...	...	...	...	W	...	
	Noon	17° 18' N	71° 47' E	...	...	...	...	
<i>S. Choice</i>	Noon	14° 18' N	66° 46' E	...	...	...	...	Course N 49° E. Distance 149 miles.
	1 P.M.	...	...	...	...	SW by W	...	Fresh steady breeze.
	4 P.M.	...	...	...	...	...	...	Sea smoother.
	8 P.M.	...	...	...	...	WSW	...	
<i>S. Clan Macleod</i>	1 A.M.	...	...	...	...	WSW	...	Sea rough. Light breeze and clear weather.
	4 A.M.	...	...	29° 698	...	...	...	Increasing breeze and cross sea.
	8 A.M.	...	...	...	...	...	...	Strong breeze and hazy weather. Ship rolling heavily and taking much water on deck.
	Noon	13° 43' N	51° 32' E	...	...	...	...	Course N 84° E. Distance 247 miles.
	1 P.M.	...	...	...	...	WSW	...	Sea rough. Fresh breeze and confused sea.
	6 P.M.	...	...	...	...	SSW	...	Heavy sea. Ship rolling heavily.
	10 P.M.	...	...	...	...	...	...	Strong breeze with high sea.
<i>S.S. Coniston</i>	Noon	7° 49' N	75° 39' E	...	...	WNW	...	Strong wind and heavy cross sea, with heavy squalls of rain.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S.S. Eschol</i>	4 A.M.	...	...	...	...	SSW	...	Moderate breeze with a heavy swell. Fine weather and clear sky.
	10 A.M.	...	...	...	...	SW	...	Fine weather and clear sky. Moderate breeze with a heavy swell.
	Noon	18° 40' N	68° 50' E	...	...	...	...	Moderate breeze with a heavy swell.
	2 P.M.	...	...	...	...	SW	...	Moderate breeze with a heavy SW swell.
	6 P.M.	...	...	...	...	WSW	...	Ditto ditto.
	10 P.M.	...	...	...	...	W by S	...	Ditto ditto.
<i>S.S. Hartville</i>	1 A.M.	...	...	...	...	Variable	...	Variable light airs and calms.
	8 A.M.	...	...	...	...	SW	...	Increasing breeze.
	Noon	12° 46' N	47° 53' E	...	...	SW	...	Brisk breeze and increasing sea. Course N 87° E. Distance 167 miles.
	1 P.M.	...	...	...	...	SW	...	Strong breeze and increasing sea.
	8 P.M.	...	...	...	...	SW	...	Decreasing breeze and falling sea.
	Mid-night	...	...	...	...	...	...	Light variable breeze and cloudy weather.
<i>S. Iris</i>	2 A.M.	...	...	...	...	SW	...	Moderate breeze with passing showers.
	6 A.M.	...	...	...	...	WSW	...	
	Noon	18° 14' N	70° 54' E	29° 7	...	...	...	Fine weather. Course N 45° E. Distance 144 miles.
	Mid-night.	...	...	...	...	...	...	Light breeze and hazy weather.
<i>S.S. John Pender</i>	1 A.M.	...	...	...	...	SW by S	...	Strong gale. Squally with rain. Shipping water constantly over all.
	4 A.M.	...	...	29° 49	80	...	...	Wind and sea moderating.
	6 A.M.	...	...	...	...	...	...	Squared yards and kept away to NW by N.
	8 A.M.	...	...	29° 52	81	...	...	Fresh gale and high sea.
	Noon	18° 15' N	60° 34' E	29° 53	84	SSW	...	Weather moderating. Sea still very high.
	6 P.M.	...	...	29° 49	86	...	...	Strong breeze and a high sea from 3 P.M. to 6 P.M. Dark and gloomy to westward.
	Mid-night.	...	...	29° 30	84	...	...	Blowing hard, and very squally and dirty.
<i>S.S. Mercedes</i>	1 A.M.	...	...	...	...	SW by S	8	Strong gale and heavy sea with squalls of rain.
	6 A.M.	...	...	...	...	...	...	Sea occasionally coming on board with great violence.
	8 A.M.	...	...	...	...	SW by S	7	Wind and sea more moderate.
	Noon	16° 37' N	65° 14' E	29° 02	89° 1	SW by S	7	Moderate gale and sea. Decks continually full of water. Sky clear. Course N 76° E. Distance 180 miles.
	8 P.M.	...	...	...	...	SW by S	7	Wind and sea moderate.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S.S. Nyansa</i>	3 A.M.	...	...	29.843	79.3	SW	4 to 5	Moderate breeze and fine weather with passing clouds. Ship rolling heavily.
	7 A.M.	...	...	29.850	84.3	SW	3 to 4	Ditto ditto.
	11 A.M.	...	...	29.849	88.3	SW	3 to 4	Ditto ditto.
	Noon	13° 17' N	65° 3' E	...	...	SW	3 to 4	Ditto ditto. Course N 48° E. Distance 278 miles.
	3 P.M.	...	...	29.854	86.3	SW	2 to 3	Fresh breeze and fine weather. Ship rolling heavily to SW swell.
	7 P.M.	...	...	29.862	83.3	...	...	Ditto ditto.
	11 P.M.	...	...	29.878	81.3	...	...	Ditto ditto.
	Noon	15° 17' N	69° 0' E	...	...	...	...	Light breeze and clear weather. Course N 46° E, distance 111 miles.
<i>S. Queen's Cliff</i>	2 P.M.	...	...	...	...	SW	...	Light breeze and fine clear weather.
	6 P.M.	...	...	...	...	WSW	...	
	10 P.M.	...	...	...	...	W	...	Fresh breeze.
	Noon	23° 26' N	67° 42' E	29.667	83.7	WSW	2 to 4	Heavy SW swell. Course N 38° E. Distance 195 miles.
<i>S.S. Tenasserim</i>	1 A.M.	...	...	...	...	SW	4	Long SW swell. Vessel rolling heavily.
	4 A.M.	...	...	29.607	83.7	SW by W	5	Breeze freshening.
	8 A.M.	...	...	29.675	84.7	WSW	4 to 5	Fresh breeze.
	Noon	23° 26' N	67° 42' E	29.667	83.7	WSW	2 to 4	Heavy SW swell. Course N 38° E. Distance 195 miles.
	4 P.M.	...	...	29.575	84.7	WSW	4	
	8 P.M.	...	...	29.597	83.7	SW	4 to 5	
	Mid-night.	...	...	29.637	83.7	SW	2 to 3	
<i>S.S. Wistow Hall</i>	1 A.M.	...	...	...	...	SSW	...	Fresh breeze and showery weather with less sea.
	10 A.M.	...	...	...	...	SSE.	...	
	Noon	18° 33' N	63° 56' E	29.712	80.2	...	...	Strong gale and heavy sea with hazy horizon. Course N 65° E; distance 240 miles.
	1 P.M.	...	...	...	...	S	...	Fresh breeze and hazy weather with heavy swell.
	6 P.M.	...	...	...	...	SSW	...	
	Mid-night.	...	...	...	...	...	...	Strong breeze and heavy southerly swell.

The chart for the day, Plate XXXIV, depicts the meteorological conditions at noon, so far as they can be ascertained from the somewhat meagre data available from the neighbourhood of the storm centre. It shows the centre still farther to the west-north-west in about Lat. 20° 33' N, and Long. 58° 52' E, close to the Arabian coast. Hence it appears that the centre had travelled about 104 miles during the preceding twenty-four hours. The diameter of the isobar of 29.5, as shown on the chart, is about the same as on the previous day, *viz.* 330 miles, but as the isobars are to a great extent conjectural,

on account of the paucity of the observations, it is by no means certain that the cyclone did not really contract considerably between the 1st and 2nd. The evidence as far as it goes, however, seems to imply that on the 2nd the storm was of about the same dimensions as on the 1st. The lowest pressure recorded on the 2nd was 29.49" at 4 A.M. on the *John Pender*. This is '32" below the normal pressure for the day and for the position then occupied by the ship; a lower reading than this, *viz.* 29.30", is entered in the log at midnight, but, as it is very doubtful, it has been disregarded. In the rear of the cyclone the pressure rose rapidly as the centre moved away to the west-north-west, but there is no evidence of any considerable change of pressure in the south of the Arabian Sea. Along the west coast of India there was a slight rise of about '03" from Mangalore to Cochin, but farther northward, as far as Karachi, the change was very trifling. No ship is known to have been near the centre of the cyclone on this day, and the *John Pender* is the only one that was well within the storm field. At noon she was about 200 miles to the south-east of the centre. At 1 A.M. a strong gale was reported with squalls and rain. At 4 A.M. the wind and sea were moderating. At 8 A.M. there was a fresh gale. At noon the weather had moderated further, but the sea was still very high. At 6 P.M. a strong breeze and a high sea were recorded, with a dark gloomy appearance to the westward. The *Wistow Hall* was, at noon, about 370 miles to the east-south-east of the centre. At 1 A.M. she recorded a fresh breeze from SSW, with showery weather and less sea; at noon, a strong gale and a heavy sea with a hazy horizon; at 1 P.M., a fresh breeze and hazy weather with a heavy swell; and at midnight a strong breeze and a heavy southerly swell. The *Arabia* was on the north-east side of the storm field, about 380 miles from the centre, at noon, on the voyage from Muscat to Karachi. At 1 A.M. she reported a fresh wind from SE, with a continuous heavy swell from S, that is to say, from four points to the right of the wind. At 8 A.M. the wind fell to a light breeze, but the tremendous swell from S continued, with thick haze on the horizon. At 1 P.M. the wind veered to SSE, and at 8 P.M. to S, the heavy swell continuing but gradually veering in advance of the wind to SSW and SW. The *Brinkburn*, which at noon was about 430 miles to the south-west of the centre, reported the weather to be clearing up; and the *Mercedes*, about 70 miles farther away from the centre, reported a strong gale from SW, by S, and a heavy sea with squalls and rain at 1 A.M.; a moderate gale from the same direction with a clear sky at noon, and the same wind with a moderate sea at 8 P.M. The rise of pressure in the rear of the cyclone considerably reduced the barometric gradients on the south-east side of it outside the cyclone proper, and the winds in this region should therefore have been weaker than on the 1st. The mean force, however, given by the noon observations of eight vessels was 4.1, which is .9 stronger than before. This is an anomaly for which no sufficient explanation readily presents itself. On the west coast of India the winds were westerly from Ratnagiri to Karachi, and north-westerly from Karwar to Cape Comorin. In the middle of the Arabian Sea, in Lat. 3° N the wind was southerly; between latitudes 13° N and 17° N it was south-westerly, and on approaching the land between latitudes 16° N and 23° N it became westerly. In the Gulf of Aden it was south-westerly. Evidently normal monsoon winds were now fully established over the greater part of the Arabian Sea.

Rain was recorded by the only two ships that were within the storm field; by one in the extreme south of the Arabian Sea, and by one off Cape Comorin, but by only two out

of twelve vessels between the storm field and the Bombay coast. On the western coast, however, from Bombay to Galle, rain was general. It was heaviest between Mangalore and Cape Comorin. At Bombay the sea had fallen much, and the influence of the cyclone upon it had disappeared, but to the southward, from Karwar to Calicut, the sea continued very rough in consequence of the establishment of the ordinary monsoon conditions in that locality.

3rd June 1881.—The following tables contain the available information for the 3rd. It is too meagre to show the general distribution of pressure over the Arabian Sea, and there is no evidence of the existence of the cyclone on this day, no information being available from that part of the Arabian Sea where the cyclone was traceable on the 2nd. It is probable that it broke up on reaching the land, for if it had continued on its west-north-west track, there would probably have been some indication of it in the observations recorded at Bushire. There is, however, no such indication, for the barometer at that station was lowest on the 1st June, after which it rose a little and remained nearly steady for about a week; and the wind remained steady at NW from the 28th May to the 9th June; whereas, if the cyclone had passed inland and had not broken up, the barometer would have fallen and the wind would have veered to N and NE. The available information shows, as far as it goes, that the normal monsoon conditions had established themselves over the eastern, southern, and western parts of the Arabian Sea. For the central and northern parts there are no data.

TABLE XXIX.—10 A.M. 3rd June 1881.

STATION.	Barometer.	Change in 24 hours.	Abnormal.	WIND.		Thermo- meter.	Humidity.	Cloud.	Rainfall.	Remarks on the weather at 10 A.M.
				Direction.	Velocity mean of day.					
	"	"	"		Miles per hour.	°	Per cent.	0 to 10	"	
Zanzibar . .	30'117	+ '025	+ '026	SW	7	77'7	80	1	...	
Aden . .	29'748	+ '014	— '060	NE	8	91'7	69	...	...	
Bushire . .	'626	+ '033	— '036	NW	7	80'8	55	...	...	
Karachi . .	'623	— '032	— '042	WSW	21	89'0	75	3	...	Strong wind.
Bhuj . .	'622	— '038	— '048	W	18	92'6	47	7	...	
Rajkot . .	'652	— '033	— '04	WNW	20	93'2	38	6	...	
Surat . .	'716	— '036	— '038	W	19	90'5	56	5	...	
Bombay . .	'751	— '033	— '044	W	15	89'9	66	5	...	Sea slight.
Ratnagiri . .	'803	— '005	+ '008	W	...	83'8	75	10	0'69	
Karwar . .	'801	— '008	— '036	NNW	...	85'5	70	6	0'23	Strong wind. Sea very rough.
Mangalore . .	'831	— '018	— '023	WNW	4	85'4	76	8	0'03	
Calicut . .	'852	+ '011	— '030	N	11	80'7	86	4	0'33	Sea rough.
Cochin . .	'879	+ '024	— '014	WNW	3	78'5	89	10	0'60	
Colombo . .	'809	+ '031	— '079	W	18	86'5	69	3	...	
Galle . .	'800	+ '004	— '078	NW	12	82'5	89	7	...	Strong wind.

TABLE XXX.—3rd June 1881.

NAME OF VESSEL.	Hour.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S.S. Brinkburn</i>	1 A.M.	...	...	...	...	SW	...	Fine weather.
	Noon	17° 30' N	68° 40' E	...	...	...	...	Fine weather. Course E by N $\frac{1}{2}$ N. Distance 158 miles.
<i>S. Canute</i>	Mid- night	...	...	...	...	...	...	Showery weather.
	2 A.M.	...	...	...	...	Variable	...	Heavy showers of rain.
	Noon	4° 33' N	64° 53' E	...	...	...	...	Cloudy weather. Swell from SW. Course N 22½° E. Distance 88 miles.
	2 P.M.	...	...	...	...	SW	...	Smart breeze and squally, with heavy rain.
	Mid- night	...	...	...	...	WSW	...	Steady breeze and clear weather. High westerly swell.
<i>S. Choice</i>	8 A.M.	...	...	...	...	WSW	...	Light steady breeze and fine weather.
	Noon	16° 19' N	68° 11' E	29.865	...	WSW	...	Course N 34° E. Distance 168 miles.
	2 P.M.	...	...	...	...	W	...	Fresh steady breeze and fine weather.
<i>S.S. Clan Macleod</i>	1 A.M.	...	...	...	...	SSW	...	Fresh breeze and cloudy weather with heavy sea.
	5 A.M.	...	...	...	...	SW by W	...	Ditto ditto.
	8 A.M.	...	...	...	...	SW by W	...	Strong breeze and heavy sea.
	Noon	14° 51' N	55° 20' E	...	...	SW by W	...	Strong breeze and hazy weather. Course N 73° E. Distance 227 miles.
	1 P.M.	...	...	...	...	WSW	...	Fresh breeze and hazy weather. Ship unable to keep her course.
	7 P.M.	...	...	...	...	...	...	Strong breeze with high sea.
	Mid- night	...	...	...	...	...	...	Ditto ditto
<i>S.S. Coniston</i>	Noon	16° 9' N	74° 55' E	...	...	NW	...	Strong wind and heavy cross sea with heavy rain squalls.
<i>S.S. Hartville</i>	1 A.M.	...	...	...	...	Variable	...	Light breeze and cloudy weather.
	8 A.M.	...	...	...	...	SW	...	Strong breeze and fine weather.
	Noon	13° 16' N	51° 18' E	...	...	WSW	...	Strong breeze and increasing southerly sea. Course N 82° E. Distance, 216 miles.
	4 P.M.	...	...	...	...	SW	...	Strong breeze and increasing sea.
	8 P.M.	...	...	...	...	SSW	...	Increasing breeze and slight haze. Increasing sea from southward.
	Mid- night	...	...	...	...	SSW	...	Strong breeze and heavy cross sea.
<i>S.S. Mercedes</i>	1 A.M.	...	...	...	...	WSW	7	Fresh gale and clear sky with a heavy SW sea.
	8 A.M.	...	...	...	...	WSW	6	Strong breeze and clear sky.
	Noon.	17° 26' N	68° 18' E	29.782	91.1	WSW	6	Wind and sea the same. Course N 75° E. Distance 190 miles.
	8 P.M.	...	...	...	...	W	6	Fine weather.
<i>S.S. Nyansa</i>	3 A.M.	...	...	29.870	80.3	SW by W	2 to 3	Fine clear weather.
	7 A.M.	...	...	29.860	84.3	WSW	2 to 3	Ship rolling heavily.
	11 A.M.	...	...	29.850	88.7	WSW	2 to 3	Ditto ditto.

NAME OF VESSEL.	HOUR.	Latitude.	Longitude.	Barometer.	Thermo- meter.	WIND.		REMARKS.
						Direction.	Force.	
<i>S. S. Nyansa</i> —contd.	Noon	15° 32' N	68° 33' E	...	...	WSW	2 to 3	Course N 53° E. Dis- tance 260 miles. Moderate breeze and fine weather. Ship roll- ing heavily.
	3 P.M.	...	...	29.847	85.3	WSW	2 to 3	
	7 P.M.	...	...	29.852	83.3	W	3 to 4	
	11 P.M.	...	...	29.850	80.3	W	3 to 4	
<i>S. Queen's Cliff</i>	Noon	17° 17' N	70° 52' E	...	...	W	...	Fresh breeze and fine wea- ther. Course N 42° E. Distance 161 miles.
<i>S. S. Wistow Hall</i>	1 A.M.	...	...	...	...	SW	...	Fresh breeze and hazy weather with showers of rain.
	Noon	19° 9' N	68° 35' E	29.709	85.2	WSW	...	Fresh breeze. Course N 82° E. Distance 267 miles.
	1 P.M.	...	...	...	...	SW	...	Moderate breeze and hazy weather with a SW swell.

CHAPTER III.

SUMMARY AND DISCUSSION OF RESULTS.

In order to bring into one view the gradual growth and decay of the cyclone from day to day, its track, and the rate of motion of the centre along that track, the principal facts relating to these points are grouped together in the following table:—

TABLE XXXI.

DATE.	North Latitude at noon	East Longitude at noon	Movement in preced- ing 24 hours	Rate of movement per-hour	Direction of movement	Lowest observed pressure.	Corre- sponding distance from Centre of cyclone.	Corre- sponding abnormal pressure.	Corre- sponding force of wind.	Diameter of isobar of 29.5.	Force of monsoon wind out- side isobar of 29.7.
of Centre of cyclone.											
1881			Miles.	Miles.		Inches.	Miles.	Inches.	Beaufort's Scale.	Miles.	Beaufort's Scale.
26th May .	13° 48'	66° 56'	...	...	...	29.69	71	-0.16	9	0	4.4
27th " .	13° 48'	66° 56'	0	0	...	29.50	44	-0.35	10	90	4.7
28th " .	15° 9'	67° 28'	102	4.2	N 21° E	28.80	12	-1.03	12	150	5.2
29th " .	16° 40'	66° 14'	132	5.5	N 37° W	27.15	0	-2.69	0	300	5.6
30th " .	18° 36'	63° 45'	208	8.7	N 51° W	29.20	90	-0.63	11	370	5.7
31st " .	19° 20'	61° 32'	152	6.3	N 71° W	29.06	80	-0.77	12	440	4.8
1st June .	19° 50'	60° 15'	90	3.7	N 67° W	29.35	110	-0.48	10	330	3.2
2nd " .	20° 33'	58° 52'	100	4.2	N 61° W	29.49	180	-0.32	8	330	4.1

The track is represented in Plate XXXV. The beginning of the track is the point marked May 27th. At this spot the cyclone originated between the 25th and 27th. The circle drawn round this point as a centre represents the isobar of 29.5, and indicates the area of that portion of the storm field within which the winds blew with great violence. Between noon of the 27th and noon of the 28th the storm moved in a NNE direction, at an average rate of 4.2 miles per hour, to the position indicated by the point marked May 28th, and its area increased very much, as shown by the circle drawn round this point. Between the 28th and 29th the cyclone moved in a NW by N direction, at the somewhat greater average rate of 5.5 miles per hour, and still further increased in area. Be-

tween the 29th and 30th it moved towards the NW at the still greater rate of 8·7 miles per hour, and continued to increase in area. Between the 30th and 31st it moved less rapidly in a WNW direction, at the rate of 6·3 miles per hour, and apparently increased still more, but of this there is some doubt. During the next two days it continued to move in a west-north-west direction at the slower rates of 3·7 and 4·2 miles per hour respectively, and it probably gradually contracted in area after the 31st. The last column of the table shows that the strength of the monsoon winds, outside the isobar of 29·7 and outside the storm field proper, gradually increased from the 26th to the 30th, and thereafter decreased, thus running a course almost parallel to that indicated by the increase and decrease of the area of the cyclone proper. The gradual increase and decrease of the rate of motion of the centre of the cyclone also runs a course nearly parallel to that indicated by the growth and decadence of the monsoon winds. This is probably more than a mere coincidence, as will presently be seen.

In order to determine the average characteristics of the cyclone, the amount of incurvature of the winds in different octants, the relation between the barometric gradients and the force of the winds, &c., and in order to provide the means of comparing the observations with theory,* the data shown in the following table have been extracted from the rough charts on which the noon observations were first entered. The headings of the several columns suffice to show the nature of the entries contained in them. The angles between the radius of the cyclone and the wind were measured from the charts with a protractor, and the gradients were determined by first measuring the distance apart from the two nearest isobars with a scale of nautical miles, and afterwards converting the distances into differences of pressure per 60 nautical miles. The barometric pressures entered in column 10 are the pressures read from the storm charts. The normal pressures of column 11 were obtained by interpolation from Mr. Dallas's pressure charts of the Arabian Sea for May and June. The abnormal pressures entered in column 12 are the differences between the numbers of columns 10 and 11. Only the noon observations of such ships as happened to lie inside the closed isobars have been entered in this table—

TABLE XXXII.

DATE.	Latitude of Ship (North).	Longitude of Ship (East).	WIND.		Distance from centre of Cyclone.	Octant of Cyclone.	Angle between Radius and Wind.	Barometric Gradient per sixty nautical miles.	Barometric Pressure.	Normal Barometric Pressure.	Abnormal.
			Direction.	Force.							
1881.					Miles.				Inches.	Inches.	Inch.
26th May .	13° 58'	65° 48'	NW	7	71	W	39°	...	29·69	29·85	—·16
27th May .	13° 45'	66° 15'	NW	8	44	W	46°	·120	·50	·85	—·35
" " "	15° 22'	67° 19'	ENE	7	115	N	53°	·113	·62	·84	—·22
" " "	16° 2'	66° 55'	NE	5	160	N	45°	·085	·67	·83	—·16
28th May .	14° 49'	67° 29'	W	11	25	S	93°	·300	·30	·83	—·53
" " "	15° 30'	66° 50'	NNW	10	50	NW	38°	·300	·44	·84	—·40
" " "	13° 35'	66° 40'	W	7	118	SW	63°	·143	·59	·84	—·25
" " "	17° 41'	67° 39'	E	9	137	N	84°	·085	·62	·81	—·19
" " "	17° 42'	65° 50'	NE	8	213	NW	75°	·067	·68	·82	—·14

DATE.	Latitude of Ship (North).	Longitude of Ship (East).	WIND.		Distance from centre of Cyclone.	Octant of Cyclone.	Angle between Radius and Wind.	Barometric Gradient per sixty nautical miles.	Barometric Pressure.	Normal Barometric Pressure.	Abnormal.
			Direction.	Force.							
1881				Miles.					Inches.	Inches.	Inch.
29th May . .	16° 52'	65° 50'	NE	12	35	NW	92°	1'500	28'70	'84	—1'14
" " " . .	15° 43'	67° 15'	SW	10	95	SE	90°	'333	29'34	'83	—'49
" " " . .	15° 15'	66° 22'	WSW	10	100	S	71°	'333	'37	'85	—'48
" " " . .	17° 40'	64° 11'	*NNE	9	150	NW	84°	'091	'50	'85	—'35
" " " . .	16° 46'	63° 53'	WNW	9	155	W	20°	'091	'51	'83	—'32
" " " . .	18° 18'	67° 48'	SE	10	157	NE	92°	'085	'52	'80	—'28
" " " . .	18° 5'	64° 16'	ENE	7	163	NW	119°	'088	'53	'82	—'29
" " " . .	13° 28'	67° 2'	SW	7	224	S	57°	'085	'60	'85	—'25
30th May . .	17° 14'	62° 50'	SW	9	112	SW	12°	'100	'40	'84	—'44
" " " . .	18° 3'	61° 46'	WNW	9	138	W	36°	'195	'43	'83	—'40
" " " . .	16° 59'	61° 48'	W	6	170	W	40°	'100	'48	'84	—'36
" " " . .	17° 50'	66° 10'	SSE	6	178	E	53°	'085	'50	'82	—'32
" " " . .	15° 50'	64° 3'	SSW	11	185	S	52°	'085	'51	'85	—'34
" " " . .	15° 50'	65° 16'	WSW	7	215	SE	95°	'085	'54	'85	—'31
31st May . .	16° 29'	61° 29'	SW	12	68	S	37°	'300	'00	'85	—'85
" " " . .	17° 10'	63° 15'	SW	6	190	SE	81°	'120	'44	'84	—'40
" " " . .	16° 15'	64° 50'	SW	9	210	S	50°	'120	'47	'85	—'38
" " " . .	16° 19'	60° 54'	SW	7	215	S	33°	'120	'48	'84	—'36
" " " . .	16° 11'	63° 3'	SW	6	245	SE	68°	'080	'53	'85	—'32
" " " . .	18° 3'	65° 30'	SSW	5	280	E	95°	'077	'57	'81	—'24
" " " . .	15° 42'	63° 57'	SSW	9	298	SE	78°	'075	'58	'83	—'25
1st June . .	17° 47'	61° 29'	SW	9	170	SE	74°	'067	'50	'83	—'33
" " " . .	16° 52'	60° 8'	SW	10	213	S	44°	'075	'56	'83	—'27
" " " . .	17° 2'	63° 32'	S	9	268	S	1°	'072	'59	'84	—'25
" " " . .	16° 0'	60° 21'	SW	6	300	SE	92°	'050	'60	'84	—'24
2nd June . .	18° 15'	60° 34'	SSW	7	200	SE	56°	'071	'53	'81	—'28

For the purpose of calculating average values of the gradient, of the angle between the radius of the cyclone and the wind, of the distance of the ship from the cyclone centre, of the barometric pressure, of the abnormal pressure and of the force of the wind, the data in the above table have been classified in three different ways; 1st, in accordance with the gradient; 2nd, in accordance with the distance from the centre; and, 3rd, in accordance with the octant of the cyclone; certain arbitrary limits of gradient and of distance having been selected to form the boundary of each class. The results are shown in the following table.

* In the subsequent calculations NNW was used by mistake for this observation of NNE. The results will be but slightly affected by this error.

TABLE XXXIII.—Average values of certain Cyclone Elements.

	CLASSIFIED WITH RESPECT TO THE GRADIENT.				CLASSIFIED WITH RESPECT TO THE DISTANCE FROM THE CENTRE OF THE CYCLONE.						CLASSIFIED WITH RESPECT TO THE OCTANT OF THE CYCLONE.							
	Limits of Gradient in inches.				Limits of distance from centre in miles.						Octant of Cyclone.							
	0.50 to .099	1.00 to 1.49	1.50 to 1.99	2.00 to 2.99	0 to 49	50 to 99	100 to 149	150 to 199	200 to 300	N	NE	E	SE	S	SW	W	NW	
Limits																		
Gradient in inches	.079	.115	.306	1.500	.640	.311	.147	.090	.081	.091	.085	.081	.110	.166	.121	.104	.136	
Angle between radius and wind in degrees.	65°	46°	66°	92°	77°	51°	53°	61°	62°	61°	92°	74°	79°	49°	37°	36°	68°	
Distance from centre in miles	206	146	68	35	35	71	120	168	240	137	157	229	214	168	115	108	144	
Pressure in inches	29.560	29.490	29.290	28.700	29.167	29.367	29.505	29.516	29.561	29.637	29.520	29.535	29.597	29.431	29.495	29.522	29.537	
Abnormal pressure in inches	—270	—331	—350	—1.140	—673	—475	—330	—315	—274	—190	—280	—280	—327	—412	—345	—318	—295	
Force observed, Beaufort's scale	7.8	7.6	10.3	12.0	10.1	9.7	8.5	6.8	7.5	7.0	10.0	5.5	7.5	9.6	8.0	7.8	8.5	
Force calculated	7.1	7.6	8.9	12.0	10.1	9.5	8.1	7.1	7.4	6.6	7.2	7.5	8.6	9.4	7.1	6.4	8.4	
Velocity observed in miles	46	45	68	90	66	62	52	39	44	40	65	31	44	61	48	47	52	
Velocity calculated in miles	41	45	59	102	66	60	49	41	43	38	42	44	53	59	41	36	51	
Number of observations	19	9	5	1	3	4	6	10	12	3	1	2	8	9	2	5	4	

The forces, according to Beaufort's scale, in the sixth line of the table have been converted into the velocities, in miles per hour, in the eighth line, by means of the following table, which rests on the authority of the British Meteorological Council:—

TABLE XXXIV.

Beaufort's scale.							Corresponding velocity of wind in miles per hour.
0	Calm	.	.	.	.	.	3
1	Light air	.	.	.	.	.	8
2	Light breeze	.	.	.	.	.	13
3	Gentle breeze	.	.	.	.	.	18
4	Moderate breeze	.	.	.	.	.	23
5	Fresh breeze	.	.	.	.	.	28
6	Strong breeze	.	.	.	.	.	34
7	Moderate gale	.	.	.	.	.	40
8	Fresh gale	.	.	.	.	.	48
9	Strong gale	.	.	.	.	.	56
10	Whole gale	.	.	.	.	.	65
11	Storm	.	.	.	.	.	75
12	Hurricane	.	.	.	.	.	90

The calculated forces and velocities in the seventh and ninth lines of table XXXIII will be explained hereafter.

The average results of all the observations except one, which cannot appropriately be combined with the rest, because of the very excessive steepness of the gradient, are as follow:—

Mean barometric gradient in inches per 60 nautical miles	. . .	123
„ angle between radius and wind	. . .	60°
„ distance from centre of cyclone in miles	. . .	169
„ pressure in inches	. . .	29.500
„ abnormal pressure in inches	. . .	—335
„ force of the wind (Beaufort's scale)	. . .	8.2
Corresponding mean velocity of the wind in miles per hour	. . .	50

The averages obtained by arranging the observations in accordance with the gradient, and with distance from the centre, show a tolerably regular increase of gradient and force with decrease of distance from the centre, but they show no such regular increase of the angle between the radius and the wind as the distance from the centre decreases. No doubt this angle is greater near the centre than farther away from it, but the observations are too few to give averages showing a regular progression. From the results obtained by arranging the observations in accordance with distance from the centre, it appears that an increase of distance from 120 to 168 miles corresponds to a decrease of '057" in the gradient, and to a decrease of 1.7 in force. With these rates of change the gradients and forces obtained by arranging the observations in accordance with the octant of the

cyclone have been reduced to what they would become at a uniform distance of 150 miles from the centre ; but as no satisfactory rate of change of the angle with change of distance from the centre can be directly determined from the observations, the angles are left unaltered. The results are shown below—

TABLE XXXV.

Octant.	Gradient.	Distance from centre.	Force on Beaufort's scale.	Corresponding velocity in miles per hour.	Angle between radius and wind.
	Inch.	Miles.			
N	·076	150	6·5	37	61°
NE	·093	150	10·2	67	92°
E	·175	150	8·3	50	74°
SE	·186	150	9·8	63	79°
S	·187	150	10·2	67	49°
SW	·079	150	6·8	39	37°
W	·054	150	6·3	36	36°
NW	·129	150	8·3	50	68°

The results given in the last two columns of this table are graphically represented by Fig. 1, Plate XXXVI, on a scale of 60 miles to an inch. The arrows are drawn so as to fly with the wind, and their lengths are proportional to the velocity. It will be at once seen by an inspection of this diagram that, although, looking from the centre, the winds in each octant of the cyclone turn towards the left hand and generally inwards towards the centre, they do not make equal angles with the radius of the cyclone in all the octants ; in other words, although, standing with the back to the wind, the centre is always on the left hand, its bearing is very different in different octants of the cyclone, being about 4 points in the west, south-west, and south octants ; about 6 points in the north and north-west octants ; about 7 points in the south-east and east octants, and about 8 points in the north-east octant. Another important deviation from perfect symmetry is that the winds in the north-east, east, south-east, and south octants are much stronger than those in the south-west, west, north-west and north octants. Now, although some departure from true symmetry is what might be expected to result from real irregularities in different parts of the cyclone and from roughness of the observations, yet there is too much that is systematic in the peculiarities above mentioned, to render it at all probable that they can be attributed to these causes alone. And besides, a departure from symmetry of the kind shown by the figure, is almost exactly what would result from the combination of a moderate south-westerly monsoon wind with a symmetrical cyclone wind ; a combination, which, judging from the intimate relation between the cyclone wind and the monsoon wind shown by the results of table XXXI, is in itself very probable. Adopting this view, it becomes possible to calculate, from the observed winds of the cyclone, two mean component parts, *viz.*, a progressive monsoon wind, and a symmetrical cyclone wind, which, when combined, shall produce resultant winds in near agreement with the actual winds of the cyclone. If the actual winds of the eight octants of the cyclone be resolved into their north and east components, and the averages of these be taken, the results will be the

north and east components of the monsoon wind, because the symmetrical parts of the cyclone winds will cancel each other, there being as much north wind as south wind, and as much east wind as west wind in a symmetrical cyclone. The north and east components of the winds corresponding to the data in the last two columns of table XXXV are given in the first and second lines of the following table:—

TABLE XXXVI.

Octant of Cyclone,	N	NE	E	SE	S	SW	W	NW	Mean.
North component of actual wind	+17.9	-49.0	-48.0	-52.2	-44.0	-6.1	+21.2	+46.0	-14.3
East " " " "	+33.4	+45.7	+13.8	-35.2	-50.6	-38.5	-29.1	+19.5	-5.2
North " " cyclone " "	+32.2	-34.7	-33.7	-37.9	-29.7	+8.2	+35.5	+60.3	
East " " " "	+37.6	+50.9	+19.0	-30.0	-45.4	-33.3	-23.9	+24.9	
Radial " " " "	+32.2	+11.5	+19.0	+5.6	+29.7	+17.7	+23.9	+25.0	+20.6
Tangential " " " "	+37.6	+59.5	+33.7	+48.0	+45.4	+29.3	+35.5	+60.2	+43.4
North " " mean cyclone " "	+20.6	-16.1	-43.3	-45.2	-20.6	+16.1	+43.3	+45.2	
East " " " " " "	+43.3	+45.2	+20.6	-16.1	-43.3	-45.2	-20.6	+16.1	
North " " " " " and mean monsoon wind combined.	+6.3	-30.4	-57.6	-59.5	-34.9	+1.8	+29.0	+30.9	
East component of mean cyclone wind and mean monsoon wind combined.	+38.1	+40.0	+15.4	-21.3	-48.5	-50.4	-25.8	+10.9	
Corresponding resultant velocity	38.6	50.2	59.6	63.2	59.7	50.4	38.8	32.8	
" " direction	N 81° E	S 53° E	S 15° E	S 20° W	S 54° W	N 88° W	N 42° W	N 20° E	
" " angle between radius and wind.	81°	82°	75°	65°	54°	47°	48°	64°	
" " barometric gradient calculated by Ferrel's formula.	.080	.121	.162	.179	.162	.122	.081	.063	.121
Observed barometric gradient, from table XXXV.	.076	.093	.175	.186	.187	.079	.054	.129	.122

The average north and east components are given in the last column. These are equivalent to a resultant monsoon wind of 15.3 miles per hour, from the direction S 21° W. The subtraction of the mean north component from each of the numbers in the first line of the table gives the numbers in the third line; and the subtraction of the mean east component from the numbers in the second line gives those in the fourth line. These two lines of numbers represent the wind that is left after eliminating the mean monsoon wind. They therefore include the symmetrical portions of the cyclone proper, and all the irregularities of the original observations. In the fifth and sixth lines of the table the north and east components given in the third and fourth lines are converted into radial and tangential components, and in the last column, the means are taken. These are, a mean radial component of 20.6 miles per hour, and a mean tangential component of 43.4 miles per hour, which are equivalent to a resultant wind of 48.0 miles per hour in a direction inclined to the radius at an angle of 64° 37'. In the seventh and eighth lines of the table the equivalent north and east components of this mean cyclone wind are given for each octant of the cyclone; and by adding respectively to these values the north and east components of the mean monsoon wind, the numbers in the ninth and tenth lines of the table are obtained; and these, converted into their equivalent resultant winds give the results in the 11th and 12th lines. In the 13th line the angles included between these winds and the radius are given; and, finally, the results of the last three lines are graphically represented by

figure 2, plate XXXVI, for comparison with figure 1, which is drawn from the actual observations. Figure 2, it will be observed, is obtained by a simple combination of a mean cyclone wind with a mean monsoon wind. It differs from figure 1 only to such an extent as might be expected from the irregularities in the observations, which are all included in figure 1, but all excluded from figure 2, by the method of calculation. The latter therefore represents the general characteristics of the cyclone better than the former, and affords a very complete and simple explanation of the absence of symmetry in the actual observed winds of the cyclone; showing that the differences on the different sides are due to the superposition on the cyclone wind of a monsoon wind which inclines the cyclone winds on the south-west side more towards the centre, but inclines those on the opposite or north-east side farther away from the centre; while it strengthens the cyclone winds on the south-east side by combining with them, and weakens those on the north-west side by opposing them without much changing their directions. The importance of these results to the navigator can hardly be overestimated. They will be reverted to hereafter when considering the general subject of cyclone indications.

Figure 2 shows that the centre of the cyclone is not the central point round which the winds at a distance of 150 miles from the centre are circulating. It happens that the wind in the north-west and south-east octants are nearly equally inclined at an angle of $64\frac{1}{2}^\circ$ to their respective radii, but the inclination of the wind in the north-east octant to its radius is $17\frac{1}{2}^\circ$ greater than this, and the inclination of the wind in the south-west octant to its radius is $17\frac{1}{2}^\circ$ less. A new central point may, however, be chosen, to the north-west of the real centre, and at such a distance from it that new radii drawn therefrom to the middle points of the wind arrows in the north-east and south-west octants shall make equal angles of $64\frac{1}{2}^\circ$ with those winds, and that new radii drawn from the new centre to the middle points of the wind arrows in the north-west and south-east octants shall have their inclinations the same as before. New radii drawn from this new central point to the middle of each of the wind arrows in the north, east, south and west octants respectively, will then make equal angles of $64\frac{1}{2}^\circ$ with each of those winds. As the winds in all the octants will then make equal angles with their respective new radii drawn towards the new centre, they may with more propriety be regarded as rotating round this new centre rather than round the centre about which the winds in the interior of the cyclone rotate; that is to say, the winds in the outer part of the cyclone, and those in the inner, may be regarded as rotating round different centres, the position of the new centre being towards the north-west of the old one.

A rigid geometrical method of finding the position of the new centre in a hypothetical case is shown by figure 3, Plate XXXVII, which is drawn to a scale of 60 miles to an inch. The radius AC is taken at 150 miles, the lines Ac in the several octants represent symmetrical cyclone winds of 50 miles per hour, each inclined at a uniform angle of 65° to its radius. The lines cb represent superposed south-west monsoon winds of 20 miles per hour, and the thick lines Ab represent the respective unsymmetrical resultants of the symmetrical cyclone wind and the monsoon wind. On the radius AC, say the one pointing to the south-west, and on the north-west side of it, construct a triangle ACB similar to the triangle of forces at the outer end of AC, making the angle BAC equal to the angle bAc, and the angle ACB equal to the angle Acb, and join the point B with dotted lines

to each of the eight points A on the circumference of the circle, thus forming with the radii of the circle and the line CB the system of eight triangles ABC, each of which is, as a little consideration will show, similar to the triangle of forces drawn at the outer end of its own base, the radius AC. Each of the triangles of this system may be conceived as having been formed by rotating its triangle of forces 65° in a left handed direction, round the point A, when Ac will coincide with AC; and then, keeping the point A fixed, magnifying the triangle until c coincides with C, when b will coincide with B. The following conclusions may easily be deduced from this construction. First, each of the lines Ab is inclined to its new radius AB at an angle of 65° , which is the same angle as that which the symmetrical cyclone wind Ac makes with its radius AC. Second, the ratio of any resultant wind Ab to its new radius AB is constant, that is, $\frac{r}{R} = \frac{r'}{R'}$, r being a resultant wind and R its new radius, and the accented letters being used to indicate any other resultant wind and its new radius; and therefore third, the angular velocity round the new centre B is constant, that is, $\frac{r \sin 65^\circ}{R} = \frac{r' \sin 65^\circ}{R'}$; and fourth, the radial component of the velocity along the new radius AB is proportional to AB, that is $\frac{r \cos 65^\circ}{R} = \frac{r' \cos 65^\circ}{R'}$; in other words, particles starting at the same time from the outer ends of the new radii, and continuing to move along them with their initial radial velocities would all arrive at the new centre B at the same time; fifth, the line CB is inclined to the left of the monsoon wind cb at an angle of 65° , and it is directed from the point on the circumference of the circle where the resultant velocity is a maximum, to the point where it is a minimum, that is, from the point where the directions of the symmetrical cyclone wind and of the monsoon wind coincide, to the point where they are directly opposed to each other. Now, these conclusions seem to render it at least probable that in an unsymmetrical cyclone of the kind represented by figure 3, the winds in the outer parts will, as they move inwards, form a new centre at B, instead of continuing to reproduce a centre at C, and if so, the line CB will represent the path of the cyclone. Applying these principles to the cyclone under discussion as represented by figure 2, it appears that, since the direction of the monsoon wind was $S\ 21^\circ\ W$, and the angle between the symmetrical cyclone wind and the radius was 65° , the mean path should have been in the direction $N\ 44^\circ\ W$. The direction of the line joining the position where the storm originated on the 27th May to that which the centre occupied on the 2nd June is $N\ 50^\circ\ W$, which agrees pretty closely with the estimated direction. The change in the direction of the path from day to day seems also to be explained by these principles. In the position where the cyclone originated the normal monsoon wind is nearly due west, and a westerly wind, combining with the cyclone wind, would cause the centre to move NNE. Farther to the northward, the normal monsoon wind comes from WSW and SW, and, accordingly, the direction of the track should here be first towards the north, and afterwards towards the north-north-west. Farther to the north-west and west, the normal monsoon wind gradually becomes more southerly, until on the coast of Arabia it is probably nearly due south, and this gradual backing of the monsoon wind should cause the path of the cyclone in these regions to change gradually from north-north-west to west-north-west. The actual motion of the cyclone, as shown by the track chart, is in general agreement with these requirements, the path having first been towards the north-north-east, and afterwards having gradually curved round by north to west-north-west, always maintaining a course about six points to the left of the normal monsoon wind of the region through which it passed.

Referring again to figure 3, it will be seen that, as the length of the path CB is known, the rate at which the centre moves along that path could be calculated, if the time taken by the air to move from the circumference to the new centre were also known. This information cannot be obtained by direct observation, but if it be assumed, as a rough approximation to the truth, that the air continues to move inwards at the same rate as that at which it is observed to be moving at the circumference, a rough estimate of the rate of progress of the storm centre may be made. In accordance with this assumption the time of passage from A to B in the case of the present storm would be—

$$\frac{AB}{(Ab) \cos 64\frac{1}{2}^\circ} = \frac{AC}{(Ac) \cos 64\frac{1}{2}^\circ} = \frac{150}{20\frac{1}{2}} = 7\cdot28 \text{ hours,}$$

and as in this time the centre would move from C to B, a distance of 47·8 miles, since $Ac : AC :: cb : CB$, that is $48\cdot0 : 150 :: 15\cdot3 : 47\cdot8$, the rate at which the centre will move, will be $47\cdot8 \div 7\cdot28 = 6\cdot6$ miles per hour. The mean rate at which the storm actually moved was 5·8 miles per hour, calculated from the daily rates given in table XXXI by weighting the individual rates in proportion to the number of observations entered in table XXXII for the two dates between which the rate applies. It appears, then, that this rough estimate of the rate of motion of the storm centre does not differ very widely from the observed rate. But even more convincing evidence of a connection between the velocity of the monsoon wind, and the rate of progress of the storm centre is perhaps afforded by the simultaneous increase and decrease of these rates shown by table XXXI. A careful consideration of figure 3, shows that the length of the path CB increases when the monsoon wind $c b$ increases, but so long as the symmetrical cyclone wind Ac remains the same, the time of passage to the new centre B, on the assumption of a uniform motion, remains the same, and therefore the rate of progress of the centre should be proportional to the velocity of the monsoon wind. On the other hand, if the symmetrical cyclone wind AC increases, while the monsoon wind cb remains the same, the path CB is shortened, but as the time of passage to the centre is proportionately shortened, the rate of progress of the centre remains unchanged. Therefore, in accordance with these views, the rate of motion of the centre depends, not on the intensity of the cyclone, but only upon the strength of the monsoon wind which combines with it. The observations of table XXXI show very distinctly that the rate of motion of the storm centre and the velocity of the monsoon wind increased and decreased together. They support, therefore, in a marked manner, the conclusions above drawn from figure 3.

It will be observed that in this discussion no notice has been taken of the upper currents of the atmosphere, and the influence exercised by them upon the motion of cyclones. If these upper currents are of considerable strength the path of the centre may be very different from that deducible from a construction like that of figure 3, but, according to Ferrel,¹ the upper currents between Latitude 15° and 20° N are, on the average, very weak in the northern summer; and, if so, the question of the motion of cyclones at this time in these latitudes need not be complicated by the consideration of the effects of the upper currents. In middle and high latitudes, however, where the upper currents are very strong, the motion of cyclones may be mainly governed by the upper currents; but even there, it is reasonable to suppose that the lower currents will act in the manner deducible from figure 3, and so modify largely the motion that would result from the action of the upper currents alone.

¹ Meteorological Researches, Part I, page 45.

In the fourteenth line of table XXXVI the calculated barometric gradients corresponding to the wind velocities and angles in the eleventh and thirteenth lines are given. These gradients are obtained from Ferrel's formula, which, for the latitude and mean temperature of Bombay, *viz.* $18^{\circ} 54' N$ and $79.8^{\circ} \text{Fahr.}$ respectively, and neglecting the small effect due of change of pressure, reduces to—

$$G = .000809 (\text{cosec. } \alpha) s + .00476 \frac{r}{s}$$

where G is the gradient in inches of mercury per 60 nautical miles, α is the angle between the radius of the cyclone and the direction towards which the wind is moving, r is the radius in miles, and s is the velocity of the wind in miles per hour. To adapt the above formula to the mean latitude of the cyclone, which, by weighting the individual daily determinations in proportion to the number of observations for that day in table XXXII, comes out $17^{\circ} 25' N$, the first term should be multiplied by $\frac{\sin 17^{\circ} 25'}{\sin 18^{\circ} 54'} = .924$, which practically is equivalent to a reduction of eight per cent. This reduction has been made. Since the factor $(\text{cosec. } \alpha)$ in the first term of Ferrel's formula for the gradient depends theoretically on friction, and there is no reason to suppose that in the open ocean the friction co-efficient can differ largely on different sides of the cyclone, there seems some doubt about the propriety of using the different values of α in the different octants for calculating the factor $(\text{cosec. } \alpha)$. The mean value 65° has therefore been used.

In the last line of table XXXVI, the average observed gradients in each octant, corrected to the uniform distance of 150 miles from the centre, are entered for comparison with the calculated values. The mean of all the calculated results is .121, which is almost identical with the mean of the observed values, *viz.* .122. There are considerable discrepancies between the calculated and observed results for one or two of the octants, which is to be expected in rough observations of this kind, but there is, notwithstanding, a very general agreement in most of the octants, and the mean calculated result for the E, SE, S, and SW octants, in which the wind velocity is above the average, agrees well with the mean observed value, the two being .156 and .157 respectively. So also for the WNW, N, and NE octants, in which the wind velocity is below the average, the mean calculated value, .086, is very close to the mean observed value, .088. Too much importance must not, however, be attached to this very near agreement, for, while, on the one hand, the process of calculating average gradients at average distances from the centre tends to make the gradients thus obtained from observation somewhat too high, and so to produce some disagreement between the observed and calculated results; on the other hand, there is reason to believe that the scale for converting wind forces into miles, somewhat exaggerates the wind velocities and unduly increases the calculated gradients, thereby tending to restore agreement between the calculated and observed results. Only in case these two tendencies should happen to produce equal effects on the calculated and observed gradients, could it be said that the formula perfectly represents the observations. The most important result is that both the calculated and the observed gradients are very much steeper on the south-east side of the cyclone than on the north-west side. Indeed, in the south-east octant, they are three times as steep as in the north-west octant. The isobars must therefore be much closer together on the south-east side than on the north-west, and it is clear that a system of concentric circles drawn round the centre of the cyclone will not truly represent them. A system of similar and similarly placed confocal ellipses with their major axes extending from south-east to north-west, and with the centre

of the cyclone in the common focus would probably best represent a system of isobars, that would be in best general agreement with the observed mean gradients. Such a system of isobars would tend to equalize the angles of inclination of the wind to the isobars in the different octants of the cyclone.

Ferrel's formula has also been employed to calculate each of the wind velocities entered in the ninth line of table XXXIII from the gradient, angle, and distance in the preceding lines of the same column. For this purpose the formula for the latitude of Bombay was used, but as the mean latitude of the cyclone was more than a degree lower, some of the smaller calculated velocities may, on this account, be as much as two or three miles too small. The high velocities, however, will be scarcely affected by this circumstance. The numbers in the seventh line are the corresponding calculated forces according to Beaufort's scale, the conversions having been made by means of table XXXIV. All that need be said about these results is that, on the whole, they are in very fair agreement with the observed velocities. This conclusion is a very valuable one, because it proves that the formula may be safely used as a guide in estimating the probabilities of rough weather on the western coast of India.

In order to determine the direction of the line joining the point on the circumference of the cyclone where the gradient is greatest to the point where it is least, the constants of the first periodical term of Bessel's formula $X = M + U' \sin(n 45^\circ + u') + \&c.$, have been calculated from the observed values of the gradient in table XXXV, the angles being reckoned from north round by east, and n representing the number of the octant. The results are $U' = .055$; $u' = 320^\circ$, from the last of which it appears that the maximum value of the periodical term occurs in the azimuth S 50° E, the minimum value at N 50° W. The latter is exactly the direction of the path of the centre of the cyclone from the point where it originated, to the point where it was last observed, so that, independently of any theoretical views, the observed fact is, that the cyclone moved from the direction of the steepest gradient to the direction of the weakest gradient.

A similar statement may be made respecting the winds and the cyclone path, *viz.* that, as an observational fact, the cyclone moved from that side of the storm circle where the wind was strongest to that side where it was weakest. These statements of fact are in perfect harmony with the conclusions drawn from figure 3, for the path of the cyclone is there shown to be in the line joining the strongest wind on one side of the cyclone to the weakest on the other, the motion being from the former to the latter; and, as in cyclones, the strongest wind is always associated with the steepest gradient, this line is also the line joining the steepest gradients on one side of the storm circle to the weakest on the other.

A similar conclusion has already been arrived at by Mr. Eliot respecting the cyclones of the Bay of Bengal. In his paper on the south-west monsoon storm of the 8th to the 19th October 1882, published in the Indian Meteorological Memoirs, Vol. II, page 155, he says, "In the case of cyclones of the transition periods, an examination of those of recent occurrence, seems to show that they advance in the direction of relative least air motion, immediately prior to the generation and motion of the vortex." Figure 3 appears to afford a satisfactory explanation of this inference from observation, for it shows that the direction of motion of the cyclone is such that the first effect of its approach is to neutralize the normal wind, and so to cause less than the normal amount of air motion. It also explains

why very violent storms are usually preceded by calms, and why, after the passage of the centre when the wind suddenly changes to the opposite direction, the storm bursts forth again with greater violence than before.

Vertical thickness of the cyclone.—It has already been mentioned that one of the vessels involved in the cyclone reported the occurrence of hail on two different occasions, once at midnight on the 29th May, and again at 8 A.M. on the 30th May. At the latter hour the vessel was probably about 100 miles to the south-west of the centre, and probably at this time the storm had almost reached its maximum intensity. It is known that in the inner parts of a cyclone, the air rises upwards and flows outwards in the upper regions of the atmosphere. This follows immediately from the observed fact that, although air is pouring into the central part from all round the circumference, the pressure in the centre remains low. It is this rapid rising, and consequent cooling, of the damp air which causes the rapid condensation of vapour, and produces the heavy rainfall observed in the central portions of the cyclone. It is also known that saturated air, at an initial temperature of 80° Fahr., cools, as it ascends, at a mean rate of about '22 of a degree Fahrenheit for every 100 feet of ascent, and as hail could not be formed until the air had cooled down to the freezing point, that is to 32°, or 48° below the initial temperature, the air must have risen about 22,000 feet before the hail was formed. It probably rose very much higher than this. The vertical thickness of the cyclone must therefore have been at least 22,000 feet.

• *Barometric curves.*—All the more important barometric curves are drawn in Plate XXXVIII. These are given to show the navigator what kind of barometric movements he may expect his instrument to make when his ship is in the immediate neighbourhood of a violent cyclone in the Arabian Sea. The arrows marked along the course of the curves show the direction of the wind and its force according to Beaufort's scale. A separate barometer scale for each curve is marked on the left of each figure. The curves are of very different shapes, although all are obtained from observations made in the same cyclone, the differences being mainly due to the different paths taken through the storm field by the different vessels. Those showing the biggest depressions are of course given by the ships which passed nearest the centre, and the lack of symmetry on the falling and rising sides of the same curve is attributable, partly to the different rates at which the vessels entered and left the storm field, and partly to a real difference in the barometric features of the south-eastern and north-western sides of the cyclone. Figures A₁, A₂, and A₃ are given by the observations of three sailing vessels that were making the outward voyage round the Cape to Bombay, figures B₁, B₂, and B₃ by those of three steamers going from Aden to Bombay, and figures C₁, C₂, and C₃ by those of three homeward bound steamers from Bombay *via* Suez. In one or two cases the curve is dotted, to indicate that the observations appear doubtful. Figures B₁, C₁, and C₂ confirm each other in showing that the gradients on the eastern side of the cyclone were much steeper than on the western side, in accordance with the result already deduced from the averages of all the available noon observations entered on the charts.

Means of avoiding the dangerous winds of a cyclone in the Arabian Sea.—A careful study of these curves, and their comparison with figure 2, will perhaps best show how the most dangerous winds in the inner parts of a cyclone in the Arabian Sea in the months of May or June may be avoided. It appears from the barometric curves and the ships' logs

that most of the ships succeeded in avoiding the centre by performing suitable manœuvres ; but it also appears that many of them passed so far into the storm field as to become involved in the violent winds circulating round the centre ; and it is evident that, if the dangerous winds are to be avoided, steps should be taken for this purpose much sooner than seems to be the usual practice. It does not appear to be generally known to navigators that, in the Arabian Sea, a fall of the barometer down to three-tenths of an inch below the normal pressure of the season is a certain indication of the existence of a cyclone. A fall to only two-tenths of an inch below the normal is but a rare occurrence, and it is almost invariably accompanied by unsettled cyclonic weather, while a fall to three tenths of an inch below the average pressure of the time of day and season of the year, is a sure indication of the formation of a decided cyclone. Of course, if the pressure nowhere falls lower than this, the cyclone is but a small one, though of its existence there can be no doubt. The probability is, however, that in most cases, the pressure will be still lower not very far away. At the time when the pressure has fallen to '3" below the normal, the wind in the north-east and south-west quadrants of the cyclone will probably have risen to a moderate or a fresh gale, but in the north-west quadrant, that towards which the whole of the storm field is probably advancing, and therefore the most dangerous one, the wind will probably have risen only to a fresh breeze, while in the south-west quadrant it will probably be blowing with the force of a strong gale. This is the time at which the propriety of changing the course of the vessel should be most carefully considered. To continue much longer on the same course would most likely be fraught with the greatest danger, whereas a judicious deviation to the right or left, according to circumstances, would, in most cases, carry the vessel in a few hours to a safe distance from the centre. The first thing to be determined is the bearing of the centre. Figure 2 shows that no uniform rule for finding this bearing is always applicable to all the octants of a cyclone in the Arabian Sea ; and, when the barometer has fallen about '3" below the normal, the rule of 10 points to the right, when facing the wind, or 6 points to the left, when standing with the back to the wind, may be about 2 points in error one way or the other. Instead of using this rule it would be better to estimate the direction of the centre by consulting figure 2, which shows how the bearing of the centre from the wind direction varied in the different octants of the cyclone of May and June 1881.

A still better estimate may be made by means of the following construction :—

- 1st*—Draw an arrow (No. 1) to represent, as in figures 4 and 5, Plate XXXVII the actual wind which is blowing at the time of observation, the length being made proportional to the force or the velocity of the wind, and the barb being drawn to represent the arrow flying with the wind.
- 2nd*—Draw another arrow (No. 2) to represent the normal monsoon wind of the time and place. No. 2 must be drawn with its head or point touching the head of No. 1.
- 3rd*—Draw a third arrow (No. 3) from the tail of No. 1 to the tail of No. 2 with its head or barbed end on the tail of No. 2. Arrow No. 3 will represent the symmetrical cyclone wind uninfluenced by the monsoon wind.
- 4th*—Draw a line inclined to arrow No. 3 at an angle of 65° to the left looking from the tail towards the head of the arrow No. 3. This line will point to the centre of the cyclone.

The above construction eliminates the influence of the monsoon wind upon the bearing of the centre. It is applicable to all the octants of the cyclone, and to the time when the barometer has fallen to about '32" below the normal, and the symmetrical cyclone wind has risen to about 48 miles per hour or to force 8 on Beaufort's scale. If the barometer has fallen more than this, and the cyclone wind has risen to a greater force than 8, the bearing of the centre will be more than 65° to the left of the direction towards which the cyclone wind is moving. Ferrel has given the following formula for finding approximately the bearing of the centre in a symmetrical cyclone, that is, the angle (α) between the radius of the cyclone and the direction towards which the symmetrical cyclone wind is blowing—

$$\text{Cotan. } \alpha = \frac{f}{\cdot 505 \sin \theta + \frac{s \sin \alpha}{r}}$$

where s is the velocity of the wind in miles per hour, θ is the latitude, f is a factor depending on friction, and r is the distance from the centre of the cyclone. Inserting in this formula the values $\alpha = 64^\circ 37'$; $\theta = 17^\circ 25'$; $s = 48$ miles; and $r = 150$ miles, which are the average results obtained on a previous page for the cyclone under discussion, the value of f comes out '212, and by using this value of f the following values of α are obtained, corresponding to certain average observed values of r and s taken from table XXXIII—

TABLE XXXVII.

Bearing of centre.	Distance of centre.	Wind velocity.	Corresponding wind force on Beaufort's scale.	Corresponding average abnormal depression of barometer.
α	r	s		
	Miles.	Miles.		Inch.
56	240	44	7·4	0·274
65	150	48	8·0	0·321
74	100	56	9·0	0·388
81	55	65	10·0	0·560
86	35	90	12·0	1·140

In the last two columns of the above table the observed force of the wind and the average abnormal depression of the barometer corresponding to the calculated bearing of the centre in the first column are given from table XXXIII. From table XXXVII a good estimate can be made of the most probable bearing of the centre of the cyclone for use in the construction just described.

The only practical difficulty in this construction is the determination of the normal monsoon wind of the time and place. Unfortunately, no charts, giving this information directly, have ever been published, but a rough estimate might be made from the wind charts of the Arabian Sea, published by the Indian Meteorological Department, or, for the present, the average monsoon wind found to have been combined with the cyclone wind in the storm of May and June 1881 might be used, *viz.*, a wind of 15·3 miles per hour from S 21° W. This would probably be suitable for the western half of the Arabian Sea. For the eastern half a more westerly direction, say WSW, would probably be preferable; but

the use, for this purpose, of almost any roughly estimated monsoon wind would give better results than those obtained by neglecting altogether to take it into account. In drawing figures 4 and 5 the monsoon wind has been assumed to be from S 21° W with a velocity of 15·3 miles per hour.

The true direction and force of the actual wind is of course supposed to have been found by observation, but it should not be forgotten that the true direction and force cannot be found by direct observation on a rapidly moving vessel. Either, then, the vessel should be stopped to make a correct observation, or allowance should be made for the wind which is produced by the motion of the vessel. This effect of the motion of the vessel can easily be eliminated from the observed wind by constructing another figure similar to the one already described. Thus :—

- 1st. Draw an arrow, No. 1, to represent the observed wind while the vessel is in motion as in figure 6, Plate XXXVII.
- 2nd. Draw another arrow, No. 2, to represent the wind produced by the motion of the ship. This, of course, will be a wind blowing in the opposite direction to that in which the vessel is moving, and of the same velocity as that of the ship.* No. 2 must be drawn with its head touching the head of No. 1.
- 3rd. Draw a third arrow, No. 3, from the tail of No. 1 to the tail of No. 2 with its head on the tail of No. 2. No. 3 will represent the actual wind, uninfluenced by the motion of the ship.

The importance of these considerations, more especially to homeward bound steamers from Bombay will be seen by the following example. Suppose the course of a vessel to be S 76° W from Bombay towards Aden, and that she is steaming at the rate of 12 miles per hour, also that the wind observed on the ship while in motion is from SSE and of force 7, or 40 miles per hour. Allowing for the effect of the motion of the vessel the actual wind will be found to be from a direction about one point more easterly than the observed wind as shown by figure 6. Suppose, also, that the monsoon wind is from WSW, blowing at the rate of 15 miles per hour. Allowing for this also, the cyclone wind is found to be from a direction 33° , or about 3 points, to the eastward of the observed wind, as in figure 6. Hence it appears that, if the bearing of the centre of the cyclone, in accordance with the usual rule, be reckoned at 6 points to the left of the observed wind, standing with the back to it, the centre will bear almost due west, whereas the true bearing, *viz.*, that reckoned from the direction of the cyclone wind would, by the same rule, be 3 points more to the south, that is SW by W. It appears, then, that in a case of this kind the application of the usual rule to the observed wind would give a very misleading result. It is therefore necessary that the effects of the motion of the ship, and of the monsoon wind, on the bearing of the centre, should both be taken into account and due allowance made for them.

Having found the bearing of the centre, it is clear that if the course of the vessel can be changed so as to make an angle of not less than 90° , or eight points, with the bearing of the centre, either to the right or to the left of the line drawn towards the centre, the vessel will not itself move any nearer to the centre, and the barometer will at once cease to fall, and soon begin to rise, unless the whole cyclone is moving bodily towards the ship or very rapidly increasing in size, in either of which cases the barometer will continue to fall, and a greater deviation of the course of the vessel from the direction of

the centre will be necessary. If, however, after changing the course of the vessel, the barometer should begin to rise, it will be a proof that the distance between the centre and the ship is increasing; while if the barometer should remain stationary it will show that the cyclone is either travelling in the same direction as the ship, or is rapidly increasing in size.

The best plan seems therefore to be to deviate not less than eight points to the right or the left of the line drawn towards the centre, to watch the barometer, and be guided by its movements, always acting in such a way as to prevent a further fall or cause a rise of the barometer by deviating from the direction of the centre as much as may be needful for this purpose. The choice of directions in which to deviate, whether to the right or left, will depend on many considerations, on sea room, on the course the vessel is steering, on the strength of the wind, on the direction in which the storm centre is moving, on the kind of ship, whether a steamer or a sailing vessel, &c. It must therefore of necessity be left to the judgment of the navigator. However, a steamer going eastward, and meeting with a wind of force 7 or 8 from any direction between NE and W round by N, with a rapidly falling barometer, would probably find it best to deviate to the right; but if the wind force does not exceed 8, and the wind is from any direction between NE and SE, it would probably be best to deviate somewhat out of her course towards the NE. A steamer going westward would probably first meet with a favourable south-easterly breeze, and in this case there is great temptation to run on and cross in front of the storm, and so out of its influence, but unless by deviating to the right the barometer can be kept from falling dangerously low, and unless the vessel can outstrip the storm, which would be shown by the gradual backing of the wind to E and NE, and after passing the centre, by a rising barometer, it would be better to heave to and wait till the cyclone passes away to the north-westward. Two steamers attempting to pass from east to west across the north semi-circle of the cyclone of May-June 1881, received so much damage as to be compelled to put back to Bombay, although in one case the barometer was reported to have fallen only to 29'4".

With respect to the motion of the storm centre, the previous investigation has shown that the rule of six points to the left of the direction towards which the normal monsoon wind blows, would have been a very good rule for indicating the direction towards which the centre of the cyclone of May-June 1881 moved. This rule is in very fair agreement with what is at present known of the paths of cyclones in the Arabian Sea, and it will probably prove to be a very good guide for the future. It is very desirable that it should be verified by detailed discussion of the path of many more storms, before placing very great confidence in it. Nevertheless, in the present state of our knowledge, it is probably the best general rule that can be given for the Arabian Sea.

In the foregoing discussion constant reference has been made to the normal barometric pressure, and to the depression of the barometer below the normal. This depression is the best guide the navigator can have to aid him in estimating the probability of rough weather. He should therefore be able to calculate for himself its amount. It is not necessarily the same thing as a simple fall of the barometer, but it is the fall below the average pressure of the time and place. For instance, on a voyage from Colombo to Karachi in June, the barometer would ordinarily fall about three-tenths of an inch, because in this month the average pressure at Karachi is so much below the average

pressure at Colombo. Such a fall, if gradual, would not indicate anything unusual in the state of the weather. Indeed in this case the depression of the barometer below the normal would be nothing, the whole fall being accounted for by the difference of the normal or average June pressures of the two places. If, however, a fall of three-tenths was observed on a voyage between Bombay and Aden in the same month, nearly the whole fall would be a real depression below the normal, because the normal pressures along this route vary very little. Such a fall on this route would therefore indicate an excessive disturbance of the ordinary weather conditions. The data required for finding the depression below the normal are—

1st.—The normal pressure of the time and place.

2nd.—The actual pressure at the time of observation.

The first is obtained directly from charts of the average pressure in each month. The second can be obtained by observation of the barometer, and by the application to the observed reading of the needful corrections, as in the following example :—

Data.—Approximate position of ship. Lat. 17° N. Long. 66° E.

Reading of barometer at 8 A.M. June 15.	29'556 inches.
Attached thermometer	83'5 degrees.
Index error of barometer	—'062 inch.
Height of barometer cistern above the sea	22 feet.

<i>Calculation.</i> —Uncorrected reading of barometer	29'556
Correction for index error of barometer	+ '062
Reading corrected for index error only	29'618
Correction for temperature (to 32° Fahr.)	— '145
Reading corrected for index error and temperature	29'473
Correction for height above the sea	+ '022
Reading* corrected for index error, temperature and to sea level	29'495
Normal Pressure read from Chart	29'82
Correction to 8 A.M. for diurnal variation	+ '025
Normal Pressure at 8 A.M.	29'845
Actual observed and corrected pressure at 8 A.M.	29'495
Depression below the normal	— '350

The corrections for temperature, to sea-level, and for diurnal variation, may be taken from the small "Barometer Manual for the use of seamen," published by the London Meteorological Office.

By making frequent observations and calculations of this kind, and plotting out the results on a large scale by the method illustrated in Plate XXXVIII, the navigator will have before him a graphic representation of the barometric features of the storm, which, combined with his observations of the wind, will enable him to decide with confidence on the best course to steer, so as to keep as far as possible from the centre of the cyclone.

One other valuable indication of rough cyclonic weather is deducible from this investigation. It is well known that cyclones raise a very high confused sea, and that the confusion becomes greater as the centre is approached. It appears, however, from the pre-

ceding discussion, that in the outer parts of the cyclone, the confusion is not so great as to prevent observation of the direction from which most of the swell is rolling, and this direction is usually found to be several points to the right of that from which the wind is blowing. It is easy to understand this fact if the wind in each octant of the cyclone raises, in its own direction, a sea which travels onward to a considerable distance from the place where it originates. For if so, the sea in one octant of the cyclone would be raised not so much by the wind in that octant, as by the wind in the adjacent octant to windward; and the sea raised by the wind in the former octant would travel into, and be felt most in, the octant to leeward. In this way the sea in any octant would come mostly from a direction to the right of that from which the wind blows, because, on account of the rotation of the wind in the cyclone, the wind in the adjacent octant to windward is from a direction to the right of the direction from which the wind blows in the first octant. In the south octant, for instance, the wind is from about south-west, while in the south-west octant it is from about west, that is, from a direction about four points to the right of south-west. If therefore the sea in the south octant is mostly raised by the wind in the south-west octant, it will come from west instead of from south-west. If this is the true explanation of the numerous observations made in the outer parts of the cyclone of May—June 1881, showing that the sea came from a direction several points to the right of the wind, it follows that, whenever a heavy sea is observed to be rolling from a direction several points to the right of the wind, the inference will be that the vessel is probably in the immediate neighbourhood of a cyclone. In the southern hemisphere, where cyclones rotate in the opposite direction, the sea should come from a direction several points to the *left* of the wind. It would be interesting to know whether this is really the case.

It should also be pointed out that whenever the south-westerly monsoon wind rises much above its normal strength, there is reason to believe that a cyclonic disturbance exists to the northward of the vessel. If such be really the case, a deviation towards the south would bring the ship into less boisterous weather.

Observations of the Direction and Velocity of the Wind at the Colaba Observatory, Bombay, on the 28th to the 31st May 1881, and their relation to the Cyclone.

The following tables contain the hourly tabulations of the direction and velocity of the wind on the 28th to the 31st May 1881, taken from the anemograms produced by the Anemograph at the Colaba Observatory, Bombay, which were kindly lent by the Director of the Observatory. The headings of the several columns of these tables explain themselves—

TABLE XXXVIII.—COLABA OBSERVATORY, BOMBAY.

Wind Observations on the 28th May 1881.

Hour.	Direction.	Velocity in miles per hour.	North component N + S—	East component E + W—	Normal North component.	Normal East component.	Abnormal North component.	Abnormal East component.	Abnormal Direction.	Abnormal Velocity.
0 to 1	SSW	7	— 65	— 27	—33	— 43	— 32	+ 16	S 27° E	4
1 to 2	SE	11	— 78	+ 78	—34	— 42	— 44	+ 120	S 70° E	13
2 to 3	SSE	15	—139	+ 57	—34	— 35	—105	+ 92	S 41° E	14
3 to 4	SSE	17	—157	+ 65	—32	— 30	—125	+ 95	S 37° E	16

Hour.	Direction.	Velocity in miles per hour.	North component N + S -	East component E + W -	Normal North component.	Normal East component.	Abnormal North component.	Abnormal East component.	Abnormal Direction.	Abnormal Velocity.
4 to 5	SE	12	-8.5	+8.5	-3.2	-2.3	-5.3	+10.8	S 64° E	12
5 to 6	SE	9	-6.4	+6.4	-3.4	-1.7	-3.0	+8.1	S 70° E	9
6 to 7	SE	13	-9.2	+9.2	-3.6	-1.3	-5.6	+10.5	S 62° E	12
7 to 8	SE	15	-10.6	+10.6	-3.7	-1.2	-6.9	+11.8	S 60° E	14
8 to 9	S	19	-19.0	0.0	-4.0	-2.3	-15.0	+2.3	S 9° E	15
9 to 10	S	18	-18.0	0.0	-4.0	-4.5	-14.0	+4.5	S 18° E	15
10 to 11	SSW	19	-17.6	-7.3	-3.5	-7.2	-14.1	-0.1	S	14
11 to 12	SSW	15	-13.9	-5.7	-3.0	-9.0	-10.9	+3.3	S 17° E	11
12 to 13	SW	12	-8.5	-8.5	-2.6	-11.2	-5.9	+2.7	S 25° E	6
13 to 14	SW	15	-10.6	-10.6	-1.9	-12.3	-8.7	+1.7	S 11° E	9
14 to 15	SW	12	-8.5	-8.5	-1.1	-13.5	-7.4	+5.0	S 34° E	9
15 to 16	SSW	19	-17.6	-7.3	-0.8	-13.5	-16.8	+6.2	S 20° E	18
16 to 17	SSW	22	-20.3	-8.4	-0.6	-13.2	-19.7	+4.8	S 13° E	20
17 to 18	SSW	21	-19.4	-8.0	-0.9	-11.6	-18.5	+3.6	S 11° E	19
18 to 19	S	26	-26.0	0.0	-1.2	-9.8	-24.8	+9.8	S 22° E	27
19 to 20	S	25	-25.0	0.0	-1.4	-7.8	-23.6	+7.8	S 18° E	25
20 to 21	S	27	-27.0	0.0	-2.3	-6.5	-24.7	+6.5	S 15° E	26
21 to 22	S	31	-31.0	0.0	-2.4	-5.9	-28.6	+5.9	S 12° E	29
22 to 23	SSE	32	-29.6	+12.2	-2.9	-5.6	-26.7	+17.8	S 34° E	32
23 to 24	SSE	32	-29.6	+12.2	-3.2	-4.7	-26.4	+16.9	S 33° E	32
Daily Resultant.	S 17° E	17	-16.7	+0.5	-2.6	-6.7	-14.1	+7.2	S 27° E	16

TABLE XXXIX.—COLABA OBSERVATORY, BOMBAY.

Wind Observations on the 29th May 1881.

Hour.	Direction.	Velocity in miles per hour.	North component N + S -	East component E + W -	Normal North component.	Normal East component.	Abnormal North component.	Abnormal East component.	Abnormal Direction.	Abnormal Velocity.
0 to 1	SSE	32	-29.6	+12.2	-3.6	-4.3	-26.0	+16.5	S 32° E	31
1 to 2	SSE	31	-28.6	+11.9	-3.7	-4.2	-24.9	+16.1	S 33° E	30
2 to 3	SSE	27	-24.9	+10.3	-3.7	-3.5	-21.2	+13.8	S 33° E	25
3 to 4	SSE	28	-25.9	+10.7	-3.5	-3.0	-22.4	+13.7	S 31° E	26
4 to 5	SSE	26	-24.0	+9.9	-3.5	-2.3	-20.5	+12.2	S 31° E	24
5 to 6	SE	21	-14.8	+14.8	-3.7	-1.7	-11.1	+16.5	S 56° E	19
6 to 7	SSE	29	-26.8	+11.1	-3.9	-1.3	-22.9	+12.4	S 29° E	26
7 to 8	SSE	33	-30.5	+12.6	-4.0	-1.2	-26.5	+13.8	S 28° E	30
8 to 9	SSE	27	-24.9	+10.3	-4.3	-2.3	-20.6	+12.6	S 31° E	24
9 to 10	S	32	-32.0	0.0	-4.3	-4.5	-27.7	+4.5	S 9° E	28
10 to 11	S	33	-33.0	0.0	-3.8	-7.2	-29.2	+7.2	S 14° E	30
11 to 12	S	32	-32.0	0.0	-3.3	-9.0	-28.7	+9.0	S 17° E	30

Hour.	Direction.	Velocity in miles per hour.	North component N + S —	East component E + W —	Normal North component.	Normal East component.	Abnormal North component.	Abnormal East component.	Abnormal Direction.	Abnormal Velocity.
12 to 13	SSW	32	-29.6	-12.2	-2.9	-11.2	-26.7	-1.0	S 3° W	27
13 to 14	SSW	33	-30.5	-12.6	-2.2	-12.3	-28.3	-0.3	S 1° W	28
14 to 15	SSW	28	-25.9	-10.7	-1.4	-13.5	-24.5	+2.8	S 7° E	25
15 to 16	SSW	26	-24.0	-9.9	-1.1	-13.5	-22.9	+3.6	S 9° E	23
16 to 17	SSW	28	-25.9	-10.7	-0.9	-13.2	-25.0	+2.5	S 6° E	25
17 to 18	SW	19	-13.4	-13.4	-1.2	-11.6	-12.2	-1.8	S 8° W	12
18 to 19	SSW	23	-21.2	-8.8	-1.5	-9.8	-19.7	+1.0	S 3° E	20
19 to 20	S	24	-24.0	0.0	-1.7	-7.8	-22.3	+7.8	S 19° E	24
20 to 21	S	21	-21.0	0.0	-2.6	-6.5	-18.4	+6.5	S 19° E	19
21 to 22	S	19	-19.0	0.0	-2.7	-5.9	-16.3	+5.9	S 20° E	17
22 to 23	SSE	18	-16.6	+6.9	-3.2	-5.6	-13.4	+12.5	S 43° E	18
23 to 24	SSE	20	-18.5	+7.7	-3.5	-4.7	-15.0	+12.4	S 40° E	19
Daily Resultant.	S 4° E	25	-24.9	+1.7	-2.9	-6.7	-22.0	+8.4	S 21° E	23.5

TABLE XL.—COLABA OBSERVATORY, BOMBAY.

Wind Observations on the 30th May 1881.

Hour.	Direction.	Velocity in miles per hour.	North component N + S —	East component E + W —	Normal North component.	Normal East component.	Abnormal North component.	Abnormal East component.	Abnormal Direction.	Abnormal Velocity.
0 to 1	SSE	21	-19.4	+8.0	-3.8	-4.3	-15.6	+12.3	S 38° E	20
1 to 2	SSE	14	-12.9	+5.4	-3.9	-4.2	-9.0	+9.6	S 47° E	13
2 to 3	SSE	23	-21.2	+8.8	-3.9	-3.5	-17.3	+12.3	S 35° E	21
3 to 4	SE	20	-14.1	+14.1	-3.7	-3.0	-10.4	+17.1	S 59° E	20
4 to 5	SE	17	-12.0	+12.0	-3.7	-2.3	-8.3	+14.3	S 60° E	16
5 to 6	SE	20	-14.1	+14.1	-3.9	-1.7	-10.2	+15.8	S 57° E	19
6 to 7	SE	20	-14.1	+14.1	-4.1	-1.3	-10.0	+15.4	S 57° E	18
7 to 8	SSE	32	-29.6	+12.2	-4.2	-1.2	-25.4	+13.4	S 28° E	29
8 to 9	SSE	28	-25.9	+10.7	-4.5	-2.3	-21.4	+13.0	S 32° E	25
9 to 10	SSE	32	-29.6	+12.2	-4.5	-4.5	-25.1	+16.7	S 34° E	30
10 to 11	S	35	-35.0	0.0	-4.0	-7.2	-31.0	+7.2	S 13° E	32
11 to 12	S	35	-35.0	0.0	-3.5	-9.0	-31.5	+9.0	S 16° E	33
12 to 13	SSW	36	-33.3	-13.8	-3.1	-11.2	-30.2	-2.6	S 5° W	30
13 to 14	S	34	-34.0	0.0	-2.4	-12.3	-31.6	+12.3	S 21° E	34
14 to 15	S	32	-32.0	0.0	-1.6	-13.5	-30.4	+13.5	S 24° E	36
15 to 16	SSW	34	-31.4	-13.0	-1.3	-13.5	-30.1	+0.5	S 1° E	30
16 to 17	S	28	-28.0	0.0	-1.1	-13.2	-26.9	+13.2	S 26° E	30
17 to 18	S	28	-28.0	0.0	-1.4	-11.6	-26.6	+11.6	S 24° E	29
18 to 19	SSW	27	-24.9	-10.3	-1.7	-9.8	-23.2	-0.5	S 1° W	23
19 to 20	S	26	-26.0	0.0	-1.9	-7.8	-24.1	+7.8	S 18° E	25

Hour.	Direction.	Velocity in miles per hour.	North component N + S =	East component E + W =	Normal North component.	Normal East component.	Abnormal North component.	Abnormal East component.	Abnormal Direction.	Abnormal Velocity.
20 to 21	SSW	27	-24.9	-10.3	-2.8	-6.5	-22.1	-3.8	S 16° W	22
21 to 22	S	25	-25.0	0.0	-2.9	-5.9	-22.1	+5.9	S 15° E	23
22 to 23	S	28	-28.0	0.0	-3.4	-5.6	-24.6	+5.6	S 13° E	25
23 to 24	S	30	-30.0	0.0	-3.7	-4.7	-26.3	+4.7	S 11° E	27
Daily Resultant.	S 6° E	25	-25.3	4.27	-3.1	-6.7	-22.2	+9.4	S 23° E	24.1

TABLE XLI.—COLABA OBSERVATORY, BOMBAY.

Wind Observations on the 31st May 1881.

Hour.	Direction.	Velocity in miles per hour.	North component N + S =	East component E + W =	Normal North component.	Normal East component.	Abnormal North component.	Abnormal East component.	Abnormal Direction.	Abnormal Velocity.
0 to 1	S	28	-28.0	0.0	-4.0	-4.3	-23.7	+4.3	S 10° E	24
1 to 2	S	27	-27.0	0.0	-4.1	-4.2	-22.9	+4.2	S 10° E	23
2 to 3	SSW	26	-24.0	-9.9	-4.1	-3.5	-19.9	-6.4	S 18° W	21
3 to 4	SSW	22	-20.3	-8.4	-3.9	-3.0	-16.4	-5.4	S 18° W	17
4 to 5	SSW	20	-18.5	-7.7	-3.9	-2.3	-14.6	-5.4	S 20° W	16
5 to 6	SSW	23	-21.2	-8.8	-4.1	-1.7	-17.1	-7.1	S 22° W	18
6 to 7	SSW	23	-21.2	-8.8	-4.3	-1.3	-16.9	-7.5	S 24° W	18
7 to 8	SSW	20	-18.5	-7.7	-4.4	-1.2	-14.1	-6.5	S 25° W	15
8 to 9	SSW	21	-19.4	-8.0	-4.7	-2.3	-14.7	-5.7	S 21° W	16
9 to 10	SSW	23	-21.2	-8.8	-4.7	-4.5	-16.5	-4.3	S 15° W	17
10 to 11	SSW	17	-15.7	-6.5	-4.2	-7.2	-11.5	+0.7	S 4° E	11
11 to 12	SW	15	-10.6	-10.6	-3.7	-9.0	-6.9	-1.6	S 13° W	7
12 to 13	SW	13	-9.2	-9.2	-3.3	-11.2	-5.9	+2.0	S 19° E	6
13 to 14	SW	13	-9.2	-9.2	-2.6	-12.3	-6.6	+3.1	S 25° E	7
14 to 15	SW	16	-11.3	-11.3	-1.8	-13.5	-9.5	+2.2	S 13° E	10
15 to 16	SW	12	-8.5	-8.5	-1.5	-13.5	-7.0	+5.0	S 36° E	9
16 to 17	SW	13	-9.2	-9.2	-1.3	-13.2	-7.9	+4.0	S 27° E	9
17 to 18	SW	13	-9.2	-9.2	-1.6	-11.6	-7.6	+2.4	S 18° E	8
18 to 19	SW	15	-10.6	-10.6	-1.9	-9.8	-8.7	-0.8	S 5° W	9
19 to 20	SW	11	-7.8	-7.8	-2.1	-7.8	-5.7	0.0	S	6
20 to 21	SW	16	-11.3	-11.3	-3.0	-6.5	-8.3	-4.8	S 29° W	9
21 to 22	SW	11	-7.8	-7.8	-3.1	-5.9	-4.7	-1.9	S 22° W	5
22 to 23	SW	14	-9.9	-9.9	-3.6	-5.6	-6.3	-4.3	S 34° W	7
23 to 24	SW	11	-7.8	-7.8	-3.9	-4.7	-3.9	-3.1	S 38° W	5
Daily Resultant.	S 29° W	17	-14.9	-8.2	-3.3	-6.7	-11.6	-1.5	S 7° W	12

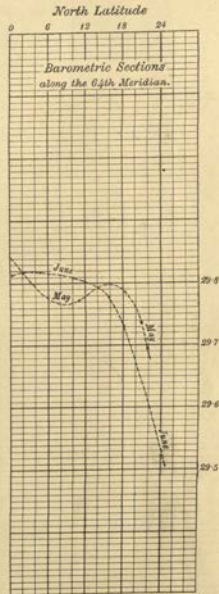
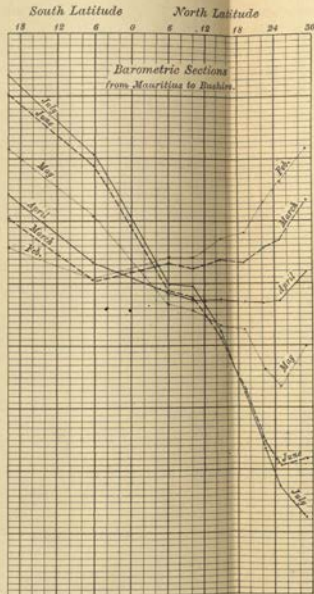
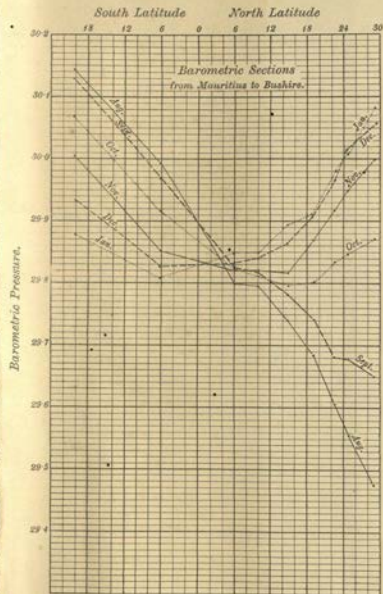
From these tables it appears that the abnormal wind first became unusually strong between 3 and 4 o'clock on the afternoon of the 28th May, when it blew from SSE. By midnight the abnormal velocity had increased to about 30 miles per hour, at which rate it

continued till noon of the 29th. After this there was a lull till about 7 A.M., of the 30th, when it again strengthened to about the same rate as before, *viz.* 30 miles per hour, and remained strong from about the same direction, SSE, until after midnight of the 31st, when it veered to SSW, and gradually died out about noon. On the 28th the resultant abnormal wind for the twenty-four hours was from S 27° E, with a velocity of 16 miles per hour; on the 29th it was from S 21° E, velocity 24 miles; on the 30th from S 23° E, velocity 24 miles; and on the 31st it was from S 7° W, velocity 12 miles. The maximum abnormal wind for any single hour during these days occurred between 1 and 2 P.M. on the 30th, when the abnormal velocity was 34 miles for the hour, and the direction of the abnormal wind was S 21° E.

The velocity of the abnormal wind at Bombay very rarely exceeds twenty miles an hour except during a local squall or when a cyclonic disturbance is in existence. In the former case the wind is always of short duration, lasting not longer than an hour or two, but in the latter, it usually continues for two or three days. Any long continued abnormal wind of more than twenty miles an hour may therefore be regarded as indicative of the existence of a cyclonic disturbance, although the barometer may have given little or no indication of it. This was the case at Bombay in the cyclone of May and June 1881, when the barometer did not fall even as much as a tenth of an inch below the normal, but when the abnormal wind blew for two or three days with an average velocity of more than twenty miles an hour.

The cyclone reached its maximum development on the 31st. At noon on the 30th the centre was almost due west of Bombay at a distance of about 620 miles, and at noon on the 31st it was a little to the north of west at a distance of about 730 miles. At the latter hour the abnormal wind at Bombay had dwindled down to only about 7 miles per hour from the southward. Now, if the whole storm field be defined as that within which the influence of the cyclone was distinctly recognisable by the strength of the abnormal winds, it follows that on the 30th Bombay was well within the field, and on the 31st, at noon, on the outer margin of it. Hence it appears that the maximum diameter of the storm field can hardly have been much less than 1,400 miles. It must not be supposed that the winds were very violent and dangerous over the whole of this area. Indeed the diameter of the dangerous central part over which winds of force 8 or more were blowing was probably not more than one-third of the whole diameter of the storm field, that is to say, not more than 500 miles at most. But surrounding the dangerous central part, and at the time when the cyclone had reached its full development, there would be a ring, somewhat less than 500 miles wide, in which the abnormal winds, or, in other words, the cyclone winds, would gradually increase in strength from nothing on the extreme outer margin to force 8 on the inner margin, and beyond which and nearer the centre, the winds would become dangerous. By regularly observing the direction and the velocity or force of the wind, and eliminating the normal monsoon wind and the wind caused by the motion of the ship, in the manner already described, it will be possible to find out when the ship is in the neighbourhood of a cyclone; and this information will always be obtainable before she has entered the dangerous central part of it.

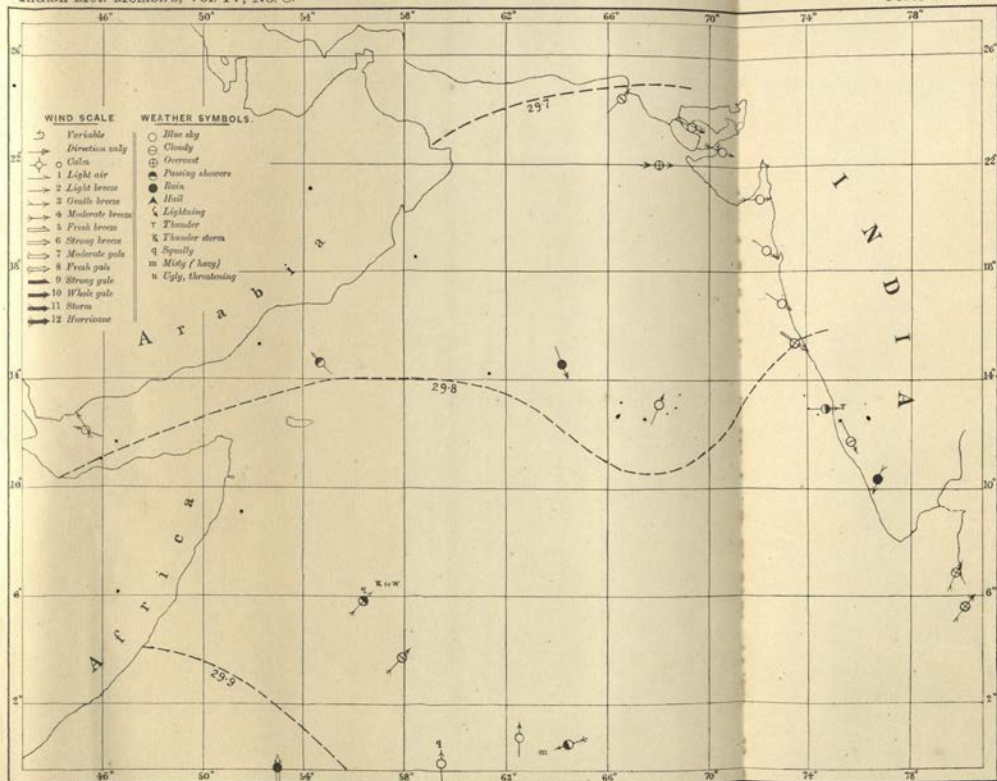
A small anemometer for measuring the velocity of the wind would be found very useful, because it is always difficult to determine accurately the force of the wind by mere estimation.



WEATHER CHART OF THE ARABIAN SEA. 1881, MAY 25th, NOON.

Indian Met. Memoirs, Vol. IV, No. 8.

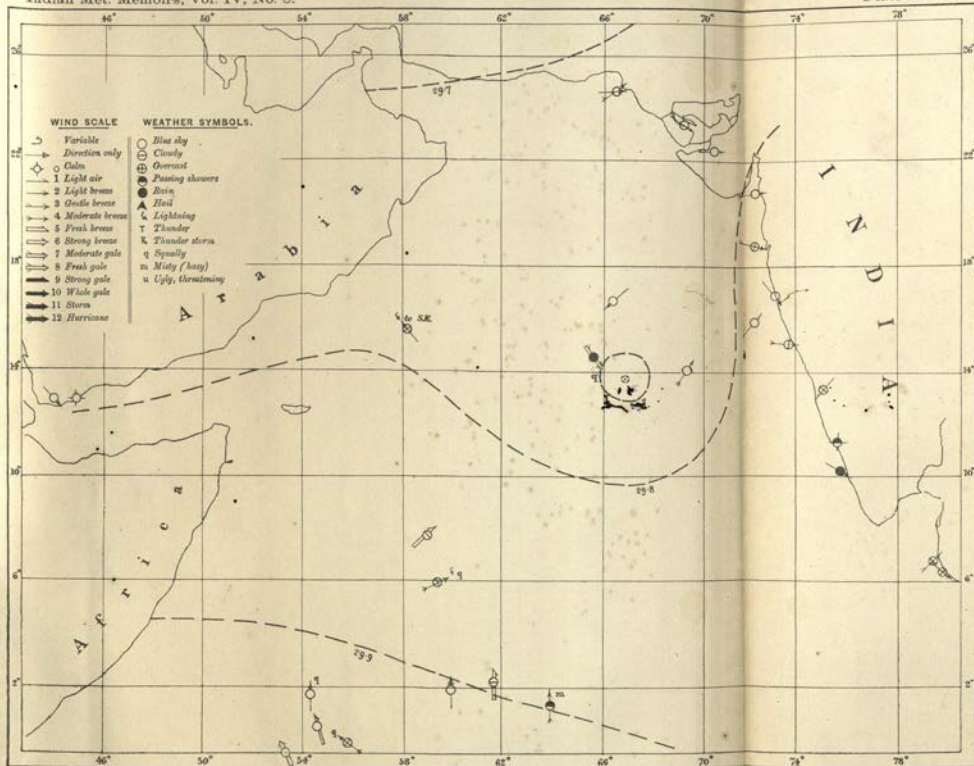
Plate XXVI.



WEATHER CHART OF THE ARABIAN SEA. 1881, MAY 26th, NOON.

Indian Met. Memoirs, Vol. IV, No. 8.

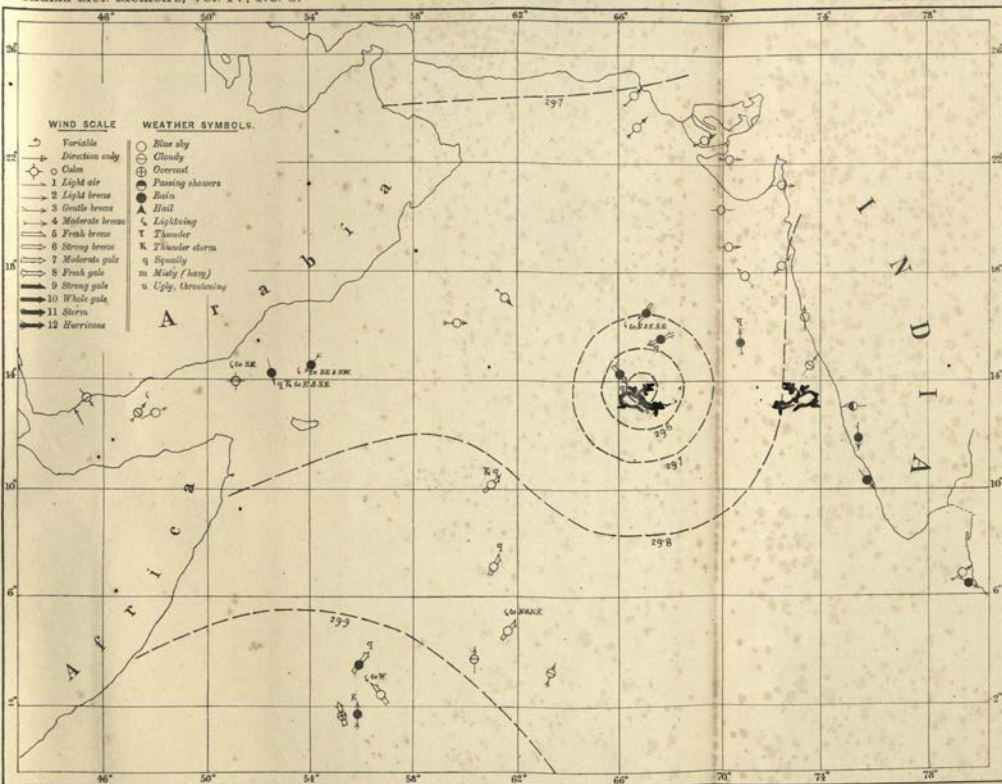
Plate XXVII.



WEATHER CHART OF THE ARABIAN SEA. 1881, MAY 27th, NOON.

Indian Met. Memoirs, Vol. IV, No. 8.

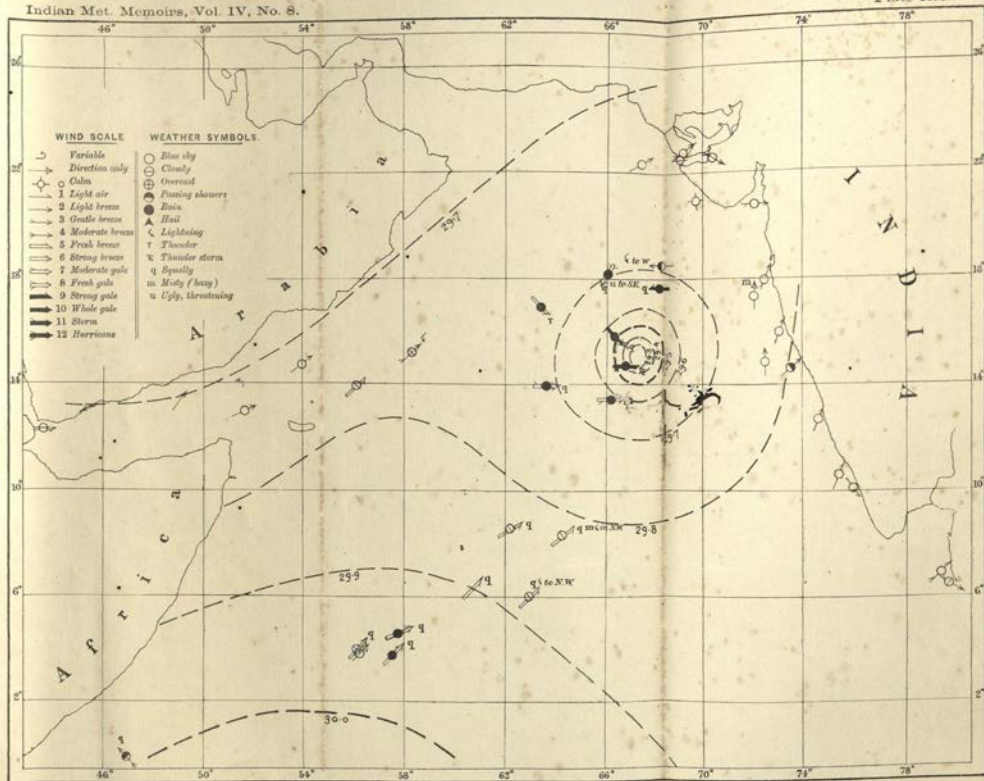
Plate XXVIII.



WEATHER CHART OF THE ARABIAN SEA. 1881, MAY 28th, NOON.

Plate XXIX.

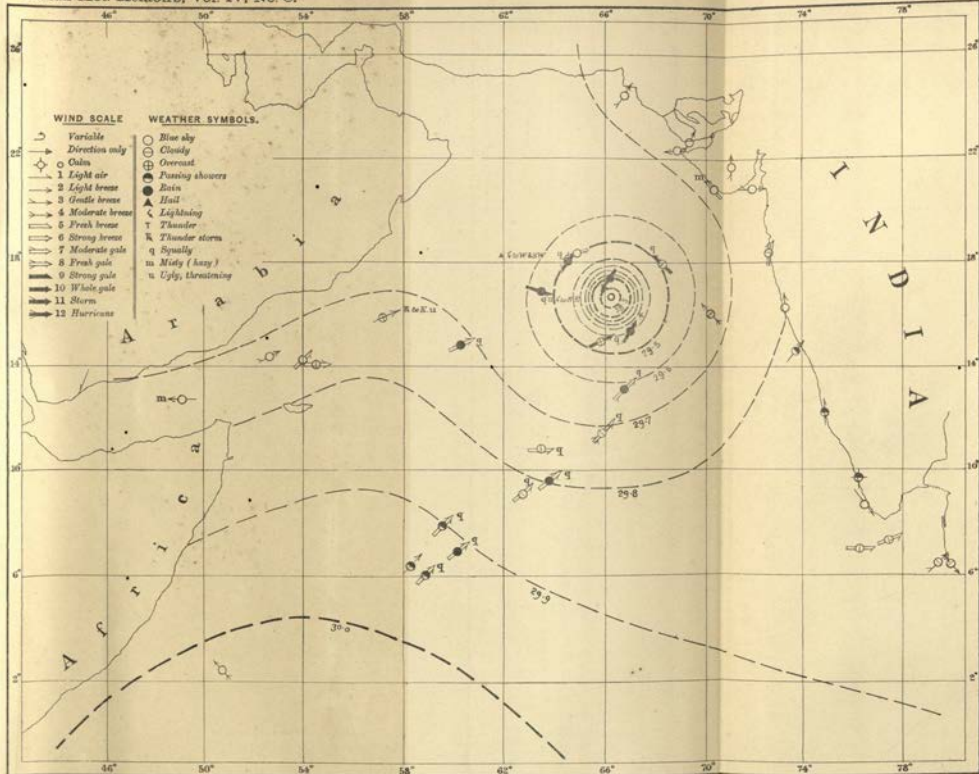
Indian Met. Memoirs, Vol. IV, No. 8.



WEATHER CHART OF THE ARABIAN SEA. 1881, MAY 29th, NOON.

Indian Met. Memoirs, Vol. IV, No. 8.

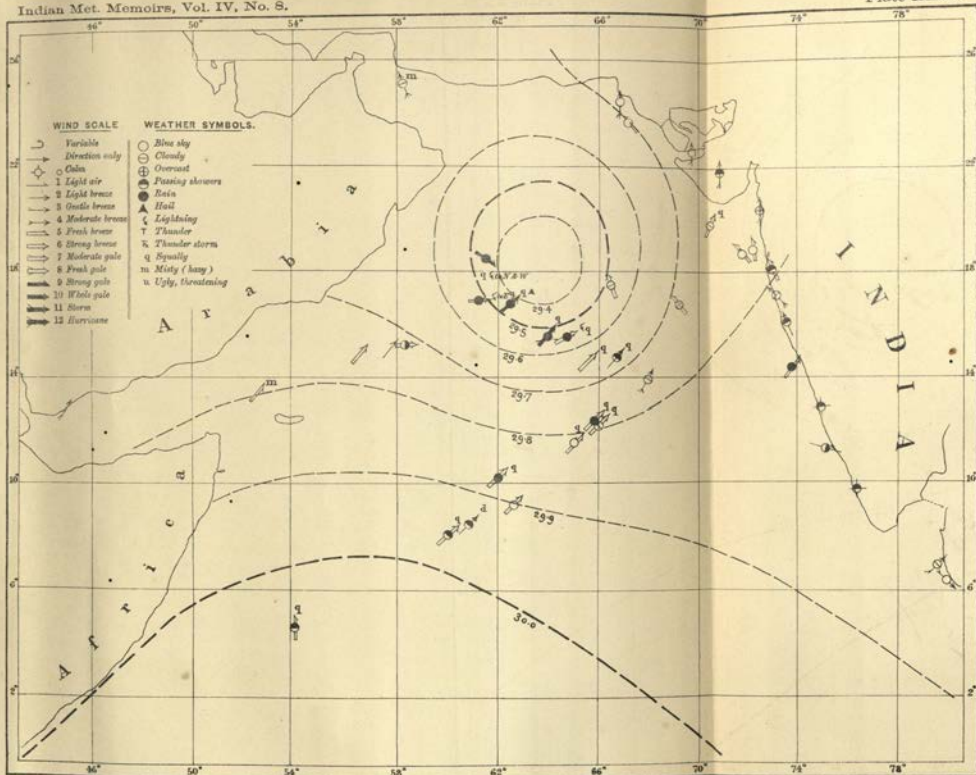
Plate XXX.



WEATHER CHART OF THE ARABIAN SEA. 1881, MAY 30th, NOON.

Indian Met. Memoirs, Vol. IV, No. 8.

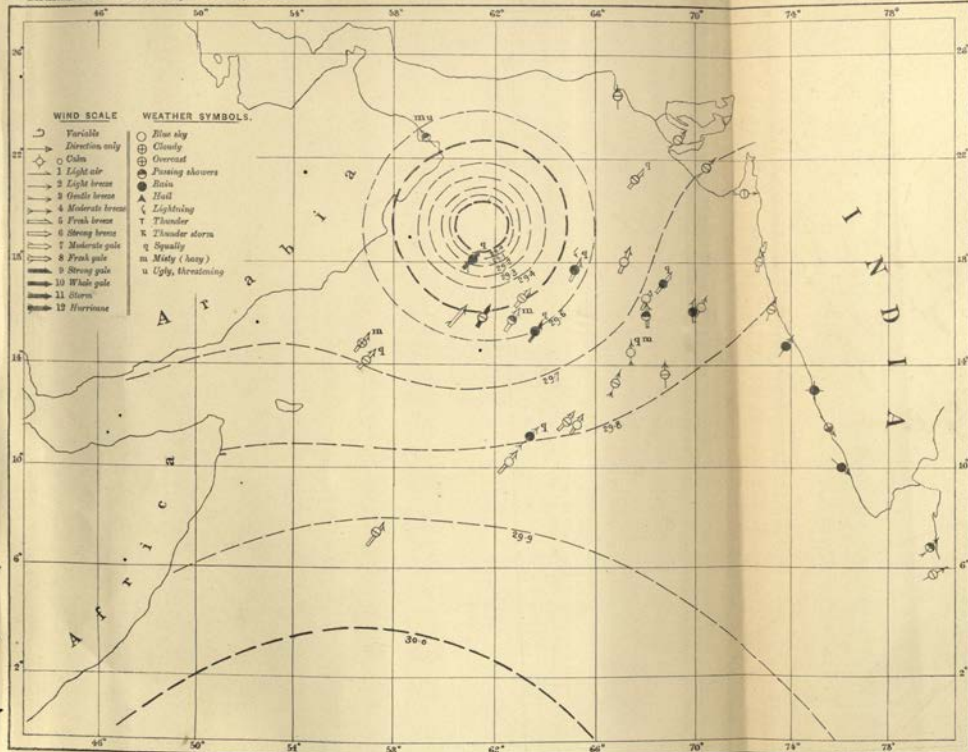
Plate XXXI.



WEATHER CHART OF THE ARABIAN SEA. 1881, MAY 31st, NOON.

Indian Met. Memoirs, Vol. IV. No. 8.

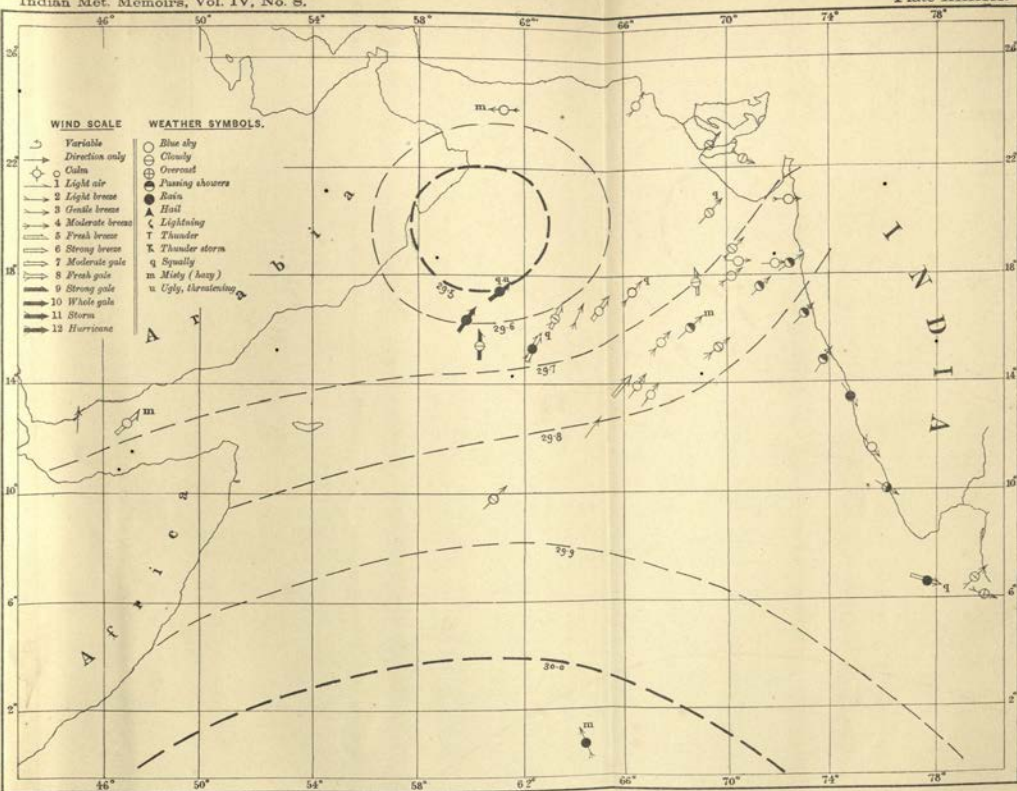
Plate XXXII.

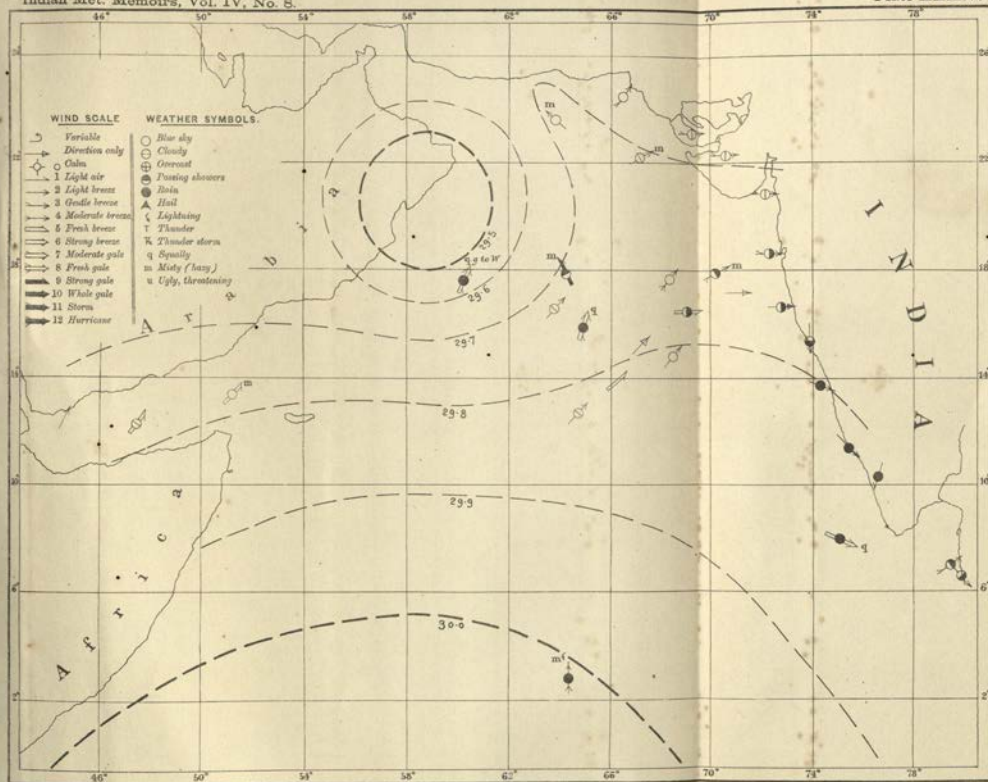


WEATHER CHART OF THE ARABIAN SEA. 1881, JUNE 1st, NOON.

Indian Met. Memoirs, Vol. IV, No. 8.

Plate XXXIII.

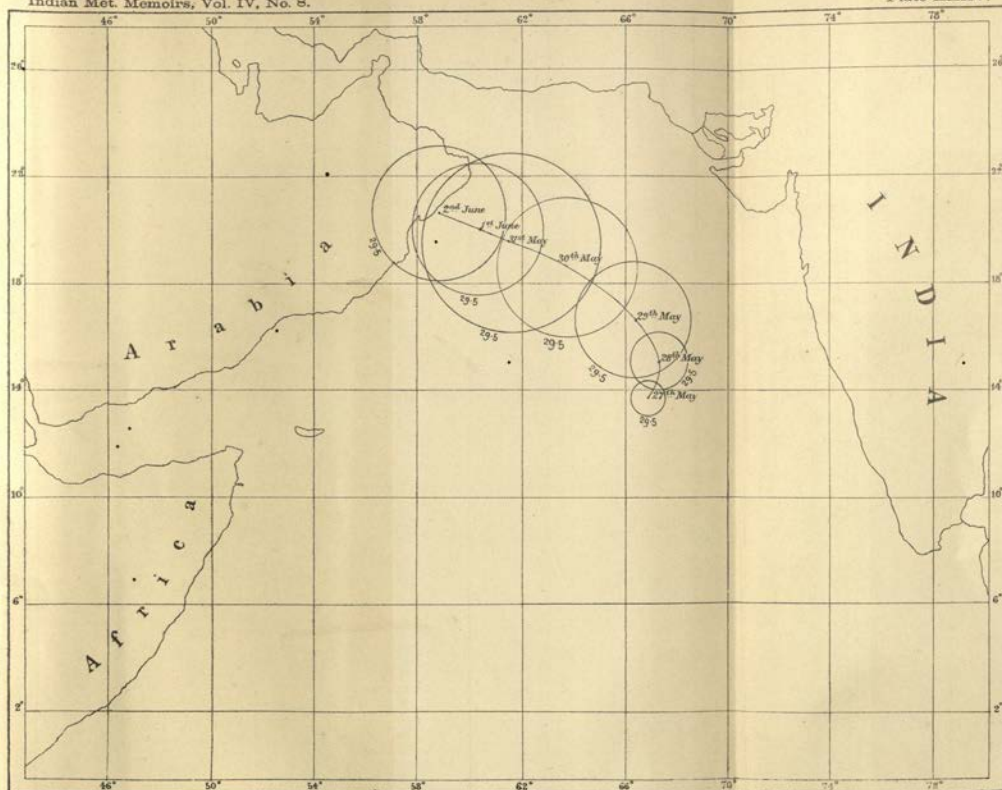




TRACK OF THE CYCLONE OF MAY AND JUNE 1881.

Indian Met. Memoirs, Vol. IV, No. 8.

Plate XXXV.



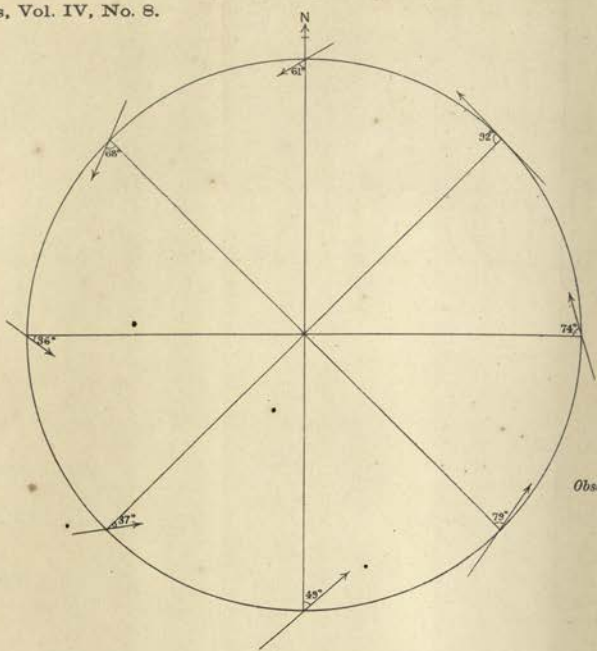


Fig. 1.

Observed Winds of the Cyclone.

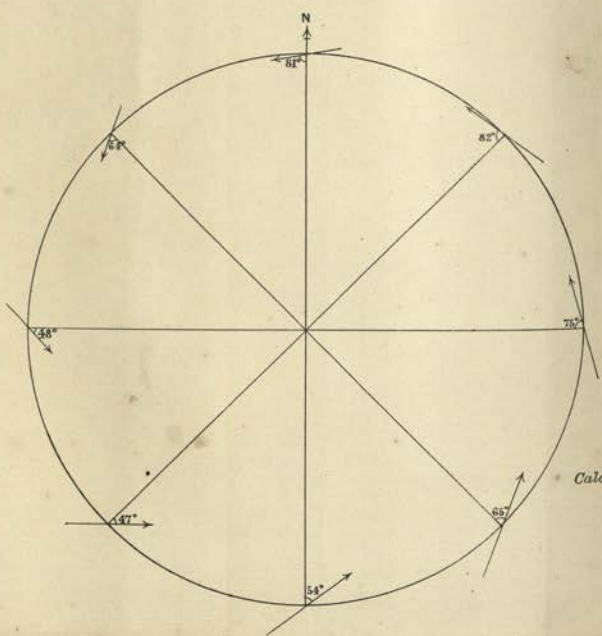


Fig. 2.

Calculated Winds of the Cyclone.

Scale Sixty Miles to an Inch.



Fig. 4.

Scale Thirty Miles to an Inch.

Fig. 5.

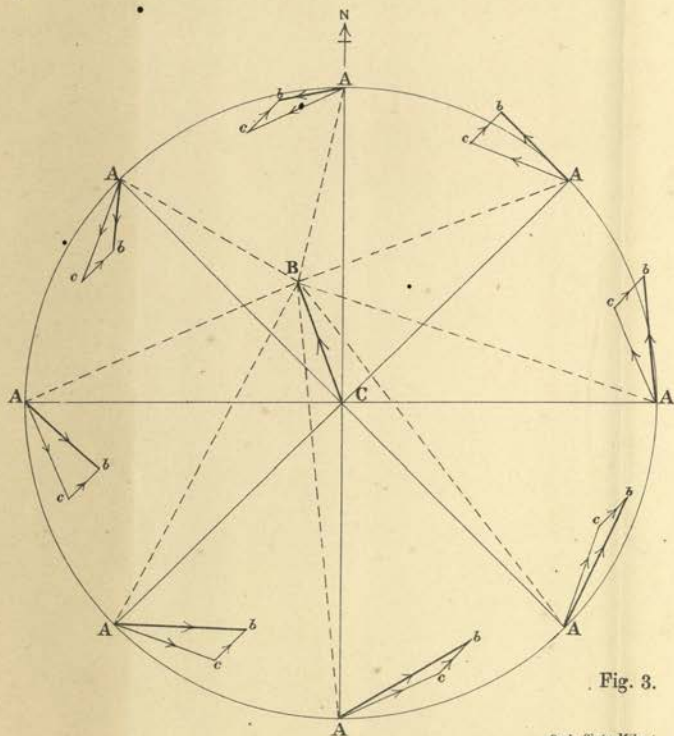
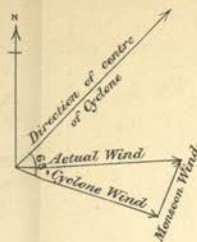


Fig. 3.

Scale Sixty Miles to an Inch.

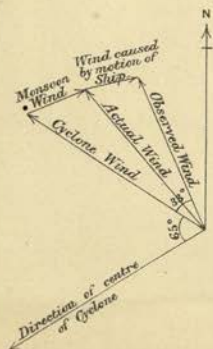
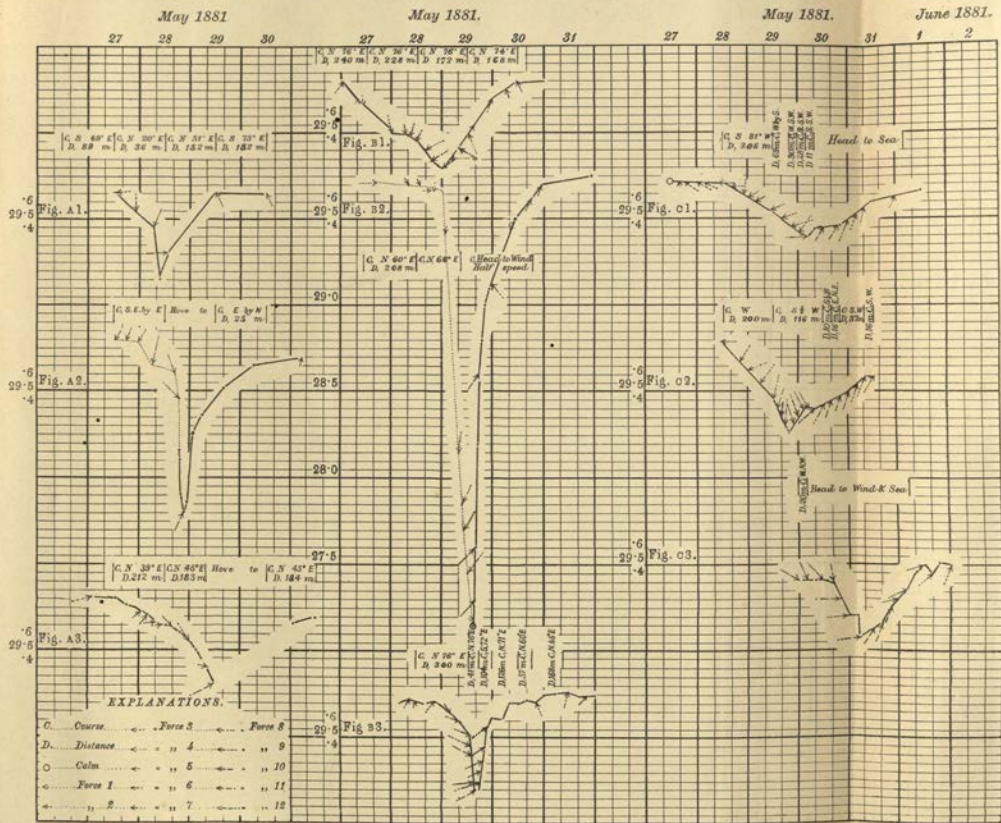


Fig. 6.

Scale Thirty Miles to an Inch.



IX.—On Temperature and Humidity observations made at Allahabad at various heights above the ground, by S. A. HILL, Meteorological Reporter to the Government of the N.-W. Provinces and Oudh.

In Volume II (page 449) will be found a discussion of a series of observations made some years ago at Alipore observatory, in which is revealed the curious fact that for some distance above the ground the mean temperature of the year increases on ascending, while during the nights of the cold weather months the increase is very marked indeed, and probably extends to a height greatly exceeding that of the upper thermometer cage in which the observations were made. With a view to determine whether a similar inversion of the normal variation of temperature with height occurs in the interior of India, as appears likely to be the case from the circumstance that the nights in the interior, especially in the dry season, are even stiller than at Calcutta, the anemograph tower of the new observatory at Allahabad was furnished near the top with a louvred pent-house in which thermometers could be exposed. This pent-house is similar in everything but size to the larger one near the ground in which the thermograph bulbs are exposed; but as its dimensions are about $5 \times 3 \times 2$ feet, and the thermometers in it are attached to uprights in the middle and not connected directly with the louvre boards, the exposures in the two pent-houses may be taken to be similar. The observations were commenced on the 1st April 1886, and still continue, though for the purposes of the present discussion only those made during the two years, from the 1st May 1886 to the 30th April 1888, have been taken.

The bulbs of the thermometers for eye observation in the lower pent-house are, like those of the thermograph, 6 feet above the ground, and in the upper cage they are at a mean height of 46 feet. In the observatory grounds there is also a set of thermometers exposed under a thatched shed of the regulation pattern, which may be taken to give the true daily range of temperature, while the instruments in the pent-house give a range somewhat too small, and the lower set a mean temperature perhaps slightly under the truth, because they are exposed close to the N.-N.-E. wall of a building of considerable size. The upper cage can only be very slightly affected by the proximity of the building, the main part of which is only 20 feet high, the tower being very slender and the air circulating freely around it. In the open shed the thermometers are from 4 to $4\frac{1}{2}$ feet above the ground. The regular observations in the shed are made daily at 6, 10, 16 and 22 hours local time, and those at the base and top of the tower at 6, 14 and 22 hours, or, more precisely, ten minutes before each of these hours, this difference of time being necessary to allow the same observers to carry on both sets of observations.

During the year 1887-88 the thermograph was dismantled for repairs, and in its absence hourly observations of the thermometers in both the tower cages and in the shed were made on two days every week. During this year also two other sets of observations were made at heights of 104 and 166 feet, on the tower of the Muir College, a building about a mile and a half from the observatory, but situated like the latter on a large open grassy space with a gentle slope and good drainage. At the College the thermometers were exposed in Stevenson screens set up on the north side of open balconies

running round the tower and close to, though above the level of the parapet or railing of each balcony, that is to say, as far away from the body of the tower as possible. Each set of thermometers, like those at the observatory, consisted of a dry bulb and a wet bulb, in addition to a maximum and a minimum thermometer. The observations, therefore, serve to determine variations of humidity as well as those of temperature. The scale errors of all the thermometers have been determined, and corrections applied to all the readings. The regular hours of observation at the College were 6, 10 and 22 hours, and hourly observations were made on four days of every month. Sanction for these extra observations was only given for twelve months, and they were therefore discontinued from the 30th April 1888.

TEMPERATURE.

The observations made at the College and those made at the observatory may be accepted as comparable, not merely because there is a good deal of similarity in the immediate surroundings of the two sites and no sensible difference of ground level, but because actual observations show the two places to have mean temperatures almost, if not quite identical. In 1882-83 it was proposed to attach the observatory to the College building; a thermometer shed was built there, and for two years, observations of temperature were recorded for comparison with those of the old observatory at Belvedere House. Afterwards the present site was fixed on, and a new comparison of two years' duration instituted. The results are here compared:—

Differences of Mean¹ Temperatures.

MONTH.	College, minus Belvedere.	Observatory, minus Belvedere.	College, minus Observatory.
January	+1°0	+1°2	—0°2
February	+1°0	+0°6	+0°4
March	+0°5	+0°4	+0°1
April	—0°2	0°0	—0°2
May	+0°2	—0°1	+0°1
June	+0°2	—0°2	+0°4
July	+0°2	+0°3	—0°1
August	+0°2	+0°4	—0°2
September	+1°0	+0°7	+0°3
October	+1°4	+1°5	—0°1
November	+1°9	+2°0	—0°1
December	+1°5	+1°0	+0°5
Year	+0°7	+0°6	+0°1

The differences in the last column are so small and irregular that they may be put down to differences in the weather of the years of comparison, and the mean temperatures at the two sites, under like conditions of exposure, may be accepted as identical month for month.

¹ Computed from the minimum, 10h. and 16h. observations.

Table I gives the mean temperature of each month at the several hours of observation, the mean maxima and minima and the mean temperature of the day, as determined from the former by means of the hourly observations detailed below :—

TABLE I A.—Mean temperature under shed, during the years 1886—88.

Months.	1886-87.								1887-88.							
	6 hours.	10 hours.	15 hours.	22 hours.	Mean.	Maximum.	Minimum.	Range.	6 hours.	10 hours.	15 hours.	22 hours.	Mean.	Maximum.	Minimum.	Range.
May	79.7	95.6	102.4	88.4	91.4	103.8	78.3	25.4	82.2	97.5	104.9	89.7	93.5	105.9	80.6	25.3
June	83.2	93.7	98.3	88.2	90.7	100.1	81.6	18.5	84.5	94.8	101.1	90.2	92.4	103.3	83.2	20.2
July	80.4	85.0	87.2	81.9	83.6	89.6	78.8	10.8	79.7	85.5	88.4	81.8	83.9	90.7	78.3	12.5
August	79.4	85.0	87.8	81.8	83.5	89.5	78.5	11.0	78.9	84.3	85.5	80.2	82.2	87.9	77.8	10.1
September	77.6	85.6	88.2	80.2	82.8	90.9	76.7	14.2	77.2	86.2	88.7	80.1	82.9	91.2	76.3	14.9
October	73.6	82.9	87.3	75.9	79.3	85.5	72.6	15.9	67.6	82.8	87.6	72.6	77.0	88.8	66.6	22.2
November	58.6	77.2	83.3	64.7	70.0	83.8	57.1	26.7	56.3	74.5	81.1	62.7	67.7	82.4	55.0	27.4
December	52.4	65.8	73.7	58.2	61.7	74.7	50.4	24.3	49.1	68.0	76.1	57.0	61.7	77.3	47.3	30.0
January	50.9	62.5	70.1	56.4	59.7	71.1	49.1	22.0	47.9	60.9	68.8	53.8	57.5	70.1	45.7	24.4
February	50.8	68.8	79.4	60.3	64.5	79.9	48.3	31.6	55.1	70.0	78.1	61.5	65.9	79.1	52.9	26.2
March	62.5	82.5	92.4	72.9	77.1	92.9	60.5	32.3	65.0	85.9	94.4	75.3	79.6	95.1	63.7	31.4
April	71.6	92.8	101.0	81.7	86.5	102.2	70.2	32.0	74.9	95.1	103.5	84.9	89.3	105.0	73.5	31.5
Year	68.4	81.5	87.6	74.2	77.6	88.9	66.8	22.1	68.2	82.1	88.2	74.2	77.9	89.7	66.7	23.0

TABLE I B.—Mean temperature at the height of 6 feet, during the years 1886—88.

Months.	1886-87.							1887-88.						
	6 hours.	14 hours.	22 hours.	Mean.	Maximum.	Minimum.	Range.	6 hours.	14 hours.	22 hours.	Mean.	Maximum.	Minimum.	Range.
May	80.2	100.3	88.9	90.9	103.3	79.0	24.3	82.7	103.3	90.4	92.1	105.1	82.3	22.7
June	83.6	98.2	88.8	90.7	100.3	82.3	18.8	84.8	100.9	90.6	91.6	102.8	84.1	18.7
July	80.5	87.4	82.2	83.4	89.8	78.7	11.1	80.0	88.7	82.2	83.5	91.1	79.0	12.1
August	79.7	88.1	82.0	83.7	89.7	78.8	10.9	79.1	86.3	80.7	83.0	88.3	78.5	9.8
September	78.2	88.5	80.7	82.9	90.2	77.2	12.9	77.6	88.6	80.6	82.8	90.3	77.2	13.1
October	74.2	85.5	76.7	79.7	86.7	73.4	13.3	69.0	85.6	73.8	78.4	86.3	68.4	17.7
November	60.3	79.5	66.4	69.8	80.7	59.3	21.3	58.0	78.1	63.7	68.7	79.0	57.7	21.2
December	53.3	70.8	59.1	61.7	72.0	52.4	19.6	50.7	73.0	58.0	61.5	74.0	50.3	23.7
January	51.8	67.6	57.0	59.1	68.9	50.7	18.2	48.9	66.7	54.8	58.1	67.6	48.4	19.2
February	52.0	75.1	61.5	63.9	76.9	50.8	26.1	55.8	75.3	62.4	64.7	76.8	55.1	21.7
March	63.9	88.5	73.6	76.8	90.3	62.3	28.0	66.4	91.6	76.3	78.2	93.3	66.0	27.3
April	72.7	98.7	83.1	86.2	100.4	72.4	28.1	76.1	102.4	86.1	87.9	104.0	75.4	28.4
Year	69.2	85.7	75.0	77.4	87.4	68.1	19.3	69.1	86.7	75.0	77.5	88.2	68.5	19.6

TABLE I C.—Mean temperature at the height of 46 feet, during the years 1886—88.

MONTHS.	1886-87.							1887-88.						
	6 hours.	14 hours.	22 hours.	Mean.	Maximum.	Minimum.	Range.	6 hours.	14 hours.	22 hours.	Mean.	Maximum.	Minimum.	Range.
May . . .	80.9	98.8	90.0	90.7	100.9	80.0	21.1	82.9	101.4	92.0	92.9	103.2	82.0	21.2
June . . .	83.9	96.7	89.8	90.6	98.2	82.2	16.7	84.1	98.3	90.2	91.4	100.6	83.3	17.3
July . . .	80.4	86.3	82.4	82.9	88.4	78.6	9.8	79.3	87.2	81.9	82.7	89.8	77.9	11.9
August . . .	79.7	87.2	82.2	83.4	88.4	78.8	9.6	78.7	84.9	80.1	81.6	86.7	77.7	9.0
September . . .	78.3	88.1	81.7	82.8	89.2	77.3	11.9	77.5	88.0	81.3	82.4	89.6	76.7	12.9
October . . .	75.3	85.9	78.9	80.4	86.8	74.1	12.7	70.4	85.9	77.2	78.2	86.8	69.2	17.5
November . . .	63.5	80.9	71.2	72.3	81.6	61.8	19.7	60.8	78.6	68.6	69.7	79.6	58.6	21.0
December . . .	55.7	71.7	63.0	63.7	72.5	53.6	18.9	53.5	73.8	63.0	63.6	74.6	51.8	22.8
January . . .	53.5	68.1	59.8	60.9	68.9	51.3	17.6	50.6	66.3	58.2	58.8	67.6	48.6	19.0
February . . .	55.5	76.0	66.4	66.6	77.6	53.2	24.4	57.1	74.8	65.3	66.3	76.7	55.3	21.4
March . . .	67.2	88.9	78.4	79.1	90.5	64.8	25.7	69.0	90.6	80.0	80.8	92.8	67.4	25.3
April . . .	75.6	97.9	86.9	87.7	99.7	73.6	26.1	77.5	100.3	88.9	89.7	102.4	76.2	26.2
Year . . .	70.8	85.5	77.6	78.4	86.9	69.1	17.8	70.1	85.8	77.2	78.2	87.5	68.7	18.8

TABLE I D.—Mean temperature at the height of 104 feet, during the year 1887-88.

MONTHS.	6 hours.	14 hours.	22 hours.	Mean.	Maximum.	Minimum.	Range.
May 1887	83.8	100.9	93.1	93.2	102.9	82.9	20.0
June "	84.3	97.8	90.1	90.9	100.3	83.4	16.9
July "	78.9	86.4	81.5	82.3	89.2	77.3	11.9
August "	78.5	84.4	80.0	80.9	86.5	77.2	9.3
September "	77.6	87.2	81.7	82.6	89.2	76.9	12.3
October "	71.7	85.3	79.1	79.0	86.4	70.8	15.6
November "	63.1	78.1	71.9	71.2	79.0	61.3	17.7
December "	57.3	73.2	66.6	65.9	74.0	55.7	18.3
January 1888	53.0	66.0	60.9	60.2	67.2	51.4	15.8
February "	59.5	74.4	67.6	67.4	76.0	57.5	18.5
March "	71.7	90.3	82.5	82.1	92.0	70.2	21.8
April "	79.5	100.0	91.2	91.1	101.5	78.4	23.1
Year	71.6	85.3	78.9	78.9	87.0	70.2	16.8

TABLE 1E.—*Mean temperature at the height of 166 feet, during the year 1887-88.*

Months.				6 hours.	14 hours.	22 hours.	Mean.	Maximum.	Minimum.	Range.
				°	°	°	°	°	°	°
May	1887	.	.	84.0	100.4	93.5	93.1	101.9	83.1	18.8
June	"	.	.	84.0	97.2	90.1	90.5	99.4	83.0	16.4
July	"	.	.	78.6	86.0	81.6	82.1	88.4	77.1	11.3
August	"	.	.	78.3	84.0	79.9	81.2	86.0	77.3	8.7
September	"	.	.	77.8	87.1	82.1	82.7	88.8	77.1	11.7
October	"	.	.	72.7	85.5	80.0	79.7	86.9	71.5	15.4
November	"	.	.	64.7	78.3	73.2	72.0	79.7	62.2	17.5
December	"	.	.	59.4	73.3	68.0	67.0	74.9	57.2	17.6
January	1888	.	.	54.2	66.0	61.6	60.5	67.7	52.2	15.5
February	"	.	.	60.7	74.0	68.7	68.0	76.2	58.3	17.8
March	"	.	.	73.5	89.9	83.4	81.8	91.6	71.0	20.6
April	"	.	.	81.0	99.4	92.0	91.3	100.9	79.1	21.8
Year	.	.	.	72.4	85.1	79.5	79.2	86.9	70.8	16.1

The tables indicate that, though the thermometer at 6 feet reads slightly lower than the one in the shed, probably for the reason above set forth, there is a considerable increase of the mean temperature on ascending from 4 to 46 feet, and a similar, though not so marked, increase in each of the higher stages, especially during the month of December. The daily range, as determined by self-registering thermometers, is also seen to diminish very considerably, both between 6 and 46 feet and between 104 and 166 feet.

For the further discussion of the variations of temperature with height, which may be seen from Table I to differ much in character at different hours of the day, it is necessary to work out the diurnal variation of temperature at each elevation. For this purpose the hourly observations have been treated, as described in Vol. I, page 63, by a process, the working of which may here, for the sake of clearness, be illustrated by an example. The hourly readings of any day run from 1 A.M. to midnight. All the hourly observations of any month having been tabulated and the means struck, these were laid off on section paper and a free-hand curve drawn through the points so found. This curve was extended backwards from 1 A.M. to the preceding midnight, and if any difference appeared between the midnight value thus found and that at the end of the series of 24 hours, it was distributed, so as to correct slightly the values for all the intervening hours, except noon, which remained unchanged. Thus the observations under the shed for the month of April give midnight values of 78.5° and 80.1° , the mean of which is 79.3° . The correction to the midnight observation is therefore $+0.8^{\circ}$ at the beginning and -0.8 at the end. At 6 A.M. the correction is $+0.4^{\circ}$ and at 6 P.M. it is -0.4° , while the noon value remains unchanged. For the intervening hours similar corrections are applied, proportionate to the distance of the given hour from noon. Having thus eliminated the effect of any progressive variation of temperature upon the hourly readings, the next step was to reduce

the results of a few days' hourly observations to what they would probably have been if such readings had been made every day throughout the period over which the observations extended. This was done by inserting under each of the regular hours of observation the mean taken from Table I, finding the difference between this and the corresponding mean of the hourly series, and applying a proportionate correction to the intervening hours. Thus the observations under the shed in April gave the following hourly means (after correction as described above) :—

6 Hours.	7 Hours.	8 Hours.	9 Hours.	10 Hours.
73'9°	76'4°	82'1°	87'6°	91'9°

Table I (both years) gives a mean at 6 hours of 73'2°, and at 10 hours of 94'0°. The requisite correction at 6 hours is therefore —0'7 and at 10 hours it is +2'1°. The correction during this interval has therefore a progressive increase of 0'7° per hour, and its values at 7 hours, 8 hours and 9 hours must be 0'0°, +0'7° and +1'4°. The, finally corrected figures for these five hours are therefore—

6 Hours.	7 Hours.	8 Hours.	9 Hours.	10 Hours.
73'2°	76'4°	82'8°	89'0°	94'0°

These are the values given in Table II. The results of the 6 feet and 46 feet series, in which the observations were made 10 minutes before each hour, have been further reduced to even hours by graphical interpolation.

Table II gives the hourly temperatures thus reduced and corrected, together with the diurnal means.

TABLE II A.—*Hourly means of temperature under shed (corrected to 2 years).*

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
0	53'9	58'4	70'6	80'4	86'4	87'0	80'9	80'2	79'1	72'8	62'0	55'5	72'3
1	52'8	57'3	69'0	78'6	85'3	85'9	80'6	80'0	78'5	72'3	61'1	54'4	71'3
2	51'9	56'3	67'5	76'8	84'1	85'0	80'3	79'8	78'1	71'7	60'3	53'4	70'4
3	51'1	55'2	66'3	75'5	83'0	84'4	80'0	79'6	77'7	71'2	59'6	52'5	69'7
4	50'4	54'3	65'4	74'2	82'0	83'8	79'8	79'4	77'4	70'8	58'8	51'7	69'0
5	49'8	53'5	64'5	73'4	81'0	83'5	79'7	79'2	77'2	70'5	58'1	51'1	68'5
6	49'4	52'9	63'8	73'2	81'0	83'8	80'0	79'2	77'4	70'6	57'4	50'7	68'3
7	49'5	53'9	66'1	76'4	84'4	86'3	81'2	80'2	79'9	72'7	59'7	50'3	70'1
8	53'3	59'2	74'1	82'8	88'4	89'5	83'0	81'8	82'2	76'9	65'9	55'6	74'4
9	58'1	65'4	79'7	89'0	92'3	92'1	84'1	83'3	84'4	80'3	71'7	62'2	78'5
10	61'7	69'4	84'2	94'0	96'5	94'3	85'3	84'6	85'9	82'8	75'9	66'9	81'8
11	64'6	72'7	87'5	97'5	99'2	96'4	87'0	85'9	88'0	84'9	78'8	70'7	84'4
12	67'3	75'6	90'1	100'0	101'4	97'9	88'2	87'1	89'6	86'7	80'5	73'5	86'5
13	68'4	77'1	92'3	101'5	103'1	99'4	88'9	87'5	91'2	87'7	81'9	74'8	87'8
14	69'3	78'3	93'7	102'4	104'0	100'4	89'2	87'8	91'7	88'5	82'8	75'8	88'7

TABLE II A.—Hourly means of temperature under shed (corrected to 2 years)—continued.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
15	69.9	79.1	93.9	102.6	104.5	100.9	88.9	87.3	91.3	88.5	83.3	76.1	88.9
16	69.5	78.8	93.4	102.2	103.7	99.7	87.8	86.7	88.5	87.5	82.2	74.9	87.9
17	67.5	77.2	91.5	101.1	102.1	98.3	86.2	85.9	86.5	84.5	76.7	71.6	85.8
18	62.9	72.4	86.8	97.4	99.9	96.4	84.9	84.8	84.4	79.2	70.0	63.9	81.9
19	60.1	67.7	81.8	91.6	96.1	94.2	84.0	83.4	82.5	77.4	68.0	61.7	79.0
20	58.3	65.1	78.6	88.1	93.3	91.8	83.1	82.3	81.9	76.3	65.8	59.8	77.0
21	56.5	62.7	76.3	85.8	90.5	90.2	82.4	81.5	80.9	75.2	64.5	58.7	75.4
22	55.1	60.9	74.1	83.3	89.0	89.2	81.8	81.0	80.1	74.2	63.7	57.6	74.2
23	54.4	59.6	71.9	81.8	87.5	88.1	81.3	80.6	79.6	73.4	62.9	56.6	73.1
Mean	58.6	65.2	78.4	87.9	92.4	91.6	83.7	82.9	83.1	78.2	68.8	61.7	77.7

TABLE II B.—Hourly means of temperature at 6 feet (corrected to 2 years and to even hours).

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
0	53.8	59.6	71.6	81.1	86.8	87.3	81.2	80.4	77.4	74.2	63.0	56.4	72.7
1	53.0	58.5	70.2	79.3	85.5	86.2	81.0	80.2	79.0	73.7	62.3	55.2	72.0
2	52.3	57.3	68.7	77.8	84.3	85.3	80.7	80.0	78.6	73.1	61.6	54.3	71.2
3	51.6	56.2	67.2	76.5	83.4	84.8	80.3	79.8	78.3	72.7	60.9	53.5	70.4
4	51.0	55.3	66.5	75.6	82.6	84.3	80.1	79.6	78.0	72.3	60.2	52.9	69.9
5	50.5	54.5	65.8	75.0	81.9	84.0	79.9	79.3	77.9	72.0	59.6	52.3	69.4
6	50.3	53.9	65.0	74.8	81.9	84.6	80.4	79.6	78.4	71.8	59.2	51.8	69.3
7	50.2	54.0	67.8	77.7	85.2	87.4	81.8	81.0	81.0	73.6	61.0	51.4	71.0
8	54.0	60.1	75.4	82.4	88.9	90.6	83.1	82.6	83.7	78.1	66.6	56.0	75.1
9	58.2	65.0	79.8	88.5	92.3	92.8	84.2	84.5	85.8	81.3	71.4	62.1	78.8
10	61.3	68.3	82.9	93.5	95.6	94.8	85.5	85.3	87.2	83.3	74.6	66.2	81.5
11	63.5	71.4	85.6	96.5	97.9	96.7	86.6	86.1	87.8	84.5	76.6	69.0	83.5
12	65.4	72.8	87.6	98.3	99.7	97.6	87.4	86.8	88.4	85.2	77.5	70.2	84.7
13	66.5	74.2	89.4	99.6	100.9	98.7	88.0	87.1	88.8	85.4	78.2	71.4	85.7
14	67.3	75.3	90.3	100.6	102.0	99.6	88.0	87.1	88.6	85.7	78.8	72.1	86.3
15	67.4	75.8	91.1	101.0	102.6	99.5	87.7	86.7	88.0	85.8	78.9	72.7	86.3
16	66.7	75.7	90.8	100.9	102.2	98.7	86.2	86.4	85.9	85.1	78.4	72.1	85.8
17	65.2	74.4	88.9	99.4	101.1	97.5	85.0	85.8	84.4	83.0	75.0	69.3	84.1
18	61.7	71.2	85.6	96.2	98.9	96.3	83.8	84.6	82.9	79.7	70.4	64.6	81.3
19	59.3	67.6	81.2	91.4	95.9	94.2	83.4	83.3	82.1	77.9	68.5	62.2	78.9
20	58.0	65.1	78.7	88.0	93.1	92.1	82.9	82.4	81.4	76.8	67.1	60.6	77.2

TEMPERATURE AND HUMIDITY

TABLE II B.—Hourly means of temperature at 6 feet (corrected to 2 years and to even hours)—continued.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Octr.	Nov.	Dec.	Year.
21	56.8	63.4	76.6	85.9	90.8	90.6	82.5	81.6	80.9	75.8	65.7	59.3	75.8
22	55.7	61.8	74.7	84.4	89.4	89.5	82.1	81.2	80.5	75.2	64.8	58.4	74.8
23	54.7	60.6	73.1	83.0	88.1	88.4	81.7	80.8	79.9	74.7	63.7	57.4	73.8
Mean	58.1	64.7	78.1	87.8	92.1	91.7	83.5	83.0	82.7	78.4	68.5	61.3	77.5

TABLE II C.—Hourly means of temperature at 46 feet (corrected to 2 years and to even hours).

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
0	56.9	63.0	76.0	84.4	87.4	87.6	81.0	80.2	80.4	76.3	67.7	60.2	75.1
1	55.9	61.7	74.5	82.6	86.0	86.7	80.5	79.9	79.9	75.6	66.6	58.9	74.0
2	55.1	60.4	73.1	80.8	84.6	86.0	80.1	79.6	79.4	74.9	65.5	57.6	73.1
3	54.3	59.2	71.7	79.3	83.7	85.3	79.8	79.4	78.9	74.3	64.4	56.6	72.2
4	53.5	58.1	70.3	78.2	82.9	84.7	79.4	79.3	78.5	73.7	63.4	55.8	71.5
5	52.7	57.0	69.0	77.1	82.3	84.1	79.4	79.2	78.2	73.1	62.6	55.1	70.8
6	51.9	56.2	68.1	76.6	82.1	84.3	79.9	79.3	78.1	72.8	62.1	54.5	70.5
7	51.9	55.6	69.7	77.9	84.1	86.1	80.9	80.3	79.8	74.0	62.5	53.8	71.5
8	54.7	60.2	74.1	82.9	87.3	88.2	82.1	81.8	82.0	76.8	65.8	57.0	74.4
9	57.7	64.2	78.2	87.7	90.6	90.1	83.3	83.3	83.6	79.5	69.1	61.4	77.4
10	60.4	67.3	81.5	91.5	93.7	92.0	84.4	84.2	85.0	81.8	73.6	65.5	80.1
11	63.0	70.5	84.1	94.6	96.0	93.8	85.5	85.1	86.1	83.5	76.0	68.7	82.2
12	65.2	72.6	86.6	96.6	97.7	95.2	86.5	85.7	86.9	84.7	77.9	70.9	83.9
13	66.4	74.2	88.5	98.2	99.2	96.4	86.8	86.0	87.8	85.6	79.0	72.2	85.0
14	67.3	75.6	89.9	99.3	100.3	97.6	86.8	86.1	88.0	85.9	79.9	72.9	85.8
15	67.6	76.5	90.7	100.3	101.1	98.3	86.5	86.2	87.0	86.0	80.3	73.4	86.2
16	67.4	76.4	91.1	100.6	101.3	98.3	85.3	86.0	85.0	85.4	79.9	73.1	85.8
17	66.4	75.4	90.1	99.4	100.4	97.2	84.4	85.6	84.2	84.0	78.0	71.5	84.7
18	64.4	72.7	87.3	97.0	98.8	96.1	83.7	84.6	83.5	81.7	75.7	69.0	82.9
19	63.0	70.3	84.3	93.1	96.3	94.5	83.0	82.9	82.9	80.7	74.2	67.2	81.0
20	61.5	68.3	81.4	90.9	94.1	92.7	82.6	82.2	82.4	79.8	72.7	65.6	79.5
21	60.1	66.7	79.9	89.3	92.4	91.2	82.3	81.5	81.9	78.9	71.4	64.2	78.3
22	58.8	65.5	78.7	87.6	90.7	89.8	82.0	81.0	81.4	78.0	70.0	62.8	77.2
23	57.8	64.3	77.5	86.1	89.0	88.6	81.5	80.6	80.9	77.1	68.8	61.5	76.1
Mean	59.7	66.4	79.8	88.8	91.8	91.0	82.8	82.5	82.6	79.3	71.1	63.7	78.3

TABLE II D.—Hourly means of temperature at 104 feet (corrected to 1 year).

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
0	58.7	64.6	79.5	87.7	90.2	88.1	80.7	79.4	80.2	76.6	69.5	64.1	76.6
1	57.6	63.6	78.0	86.1	88.7	87.2	80.3	79.1	79.6	75.4	68.3	62.9	75.6
2	56.6	62.7	76.5	84.6	87.3	86.4	79.9	78.9	79.1	74.3	67.1	61.7	74.6
3	55.7	61.8	75.0	83.2	85.9	85.6	79.5	78.7	78.7	73.4	65.9	60.6	73.7
4	54.8	61.0	73.7	81.9	84.7	84.8	79.1	78.4	78.3	72.8	64.7	59.5	72.8
5	54.0	60.2	72.7	80.7	84.1	84.4	78.8	78.2	77.9	72.2	63.5	58.4	72.3
6	53.0	59.5	71.7	79.5	83.8	84.3	78.9	78.5	77.6	71.7	63.1	57.3	71.6
7	51.9	58.9	71.3	80.5	85.2	85.3	79.9	78.6	78.3	71.9	62.9	56.3	71.8
8	52.0	59.7	74.9	83.8	88.6	86.9	80.9	79.7	80.2	73.9	64.0	58.0	73.6
9	56.2	62.9	78.4	88.3	92.7	88.8	82.3	81.0	82.2	77.1	68.5	62.5	76.7
10	60.2	66.5	82.3	91.9	95.3	91.1	83.6	82.4	84.0	80.5	72.5	67.8	79.8
11	62.7	69.8	85.2	94.5	97.7	93.0	84.8	83.5	85.0	82.4	74.6	69.7	81.9
12	64.2	71.5	87.5	96.8	99.0	95.1	85.6	84.1	86.0	83.6	76.3	71.4	83.4
13	65.2	73.2	89.3	98.9	100.2	96.7	86.2	84.5	86.8	84.6	76.6	72.4	84.6
14	66.0	74.4	90.3	100.0	100.9	97.8	86.4	84.4	87.2	85.3	78.1	73.2	85.3
15	66.9	75.3	91.1	101.0	101.4	98.7	86.0	83.4	87.6	85.6	78.0	73.7	85.7
16	67.1	75.6	91.6	101.5	101.1	99.0	85.5	82.9	87.8	85.4	77.4	73.5	85.7
17	65.5	75.2	91.3	100.7	100.5	97.1	84.4	82.3	87.1	84.6	76.5	72.3	84.9
18	65.6	73.8	88.9	98.9	98.8	94.9	83.3	81.8	85.8	83.9	75.6	71.3	83.6
19	64.7	72.5	87.2	96.6	97.0	93.4	82.9	81.2	84.8	82.7	74.7	70.1	82.3
20	63.3	70.9	85.6	94.8	95.2	92.1	82.4	80.7	83.8	81.6	73.7	68.9	81.1
21	62.0	69.5	84.0	93.5	94.2	91.1	81.9	80.3	82.8	80.5	72.8	67.8	80.0
22	60.9	67.6	82.5	91.2	93.1	90.1	81.5	80.0	81.7	79.1	71.9	66.6	78.8
23	59.8	65.8	81.0	89.4	91.7	89.1	81.1	79.7	80.8	77.7	70.7	65.3	77.7
Mean	60.2	67.4	82.1	91.1	93.2	90.9	82.3	80.9	82.6	79.0	71.2	65.9	78.9

TABLE II E.—Hourly means of temperature at 166 feet (corrected to 1 year).

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
0	59.6	65.9	80.2	88.4	90.4	88.2	80.9	78.9	80.7	78.3	71.9	65.9	77.4
1	58.6	64.7	78.8	86.9	88.8	87.2	80.6	78.6	80.1	77.3	70.4	64.7	76.4
2	57.6	63.6	77.5	85.5	87.2	86.2	80.2	78.4	79.5	76.3	69.0	63.5	75.4
3	56.7	62.6	76.3	84.1	85.6	85.3	79.8	78.2	79.0	75.3	67.7	62.3	74.4
4	55.8	61.7	75.3	82.7	84.3	84.6	79.3	78.1	78.6	74.4	66.6	61.2	73.6

TABLE II E.—Hourly means of temperature at 166 feet (corrected to 1 year)—continued.

Hours.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
5	55°0	61°0	74°3	81°8	83°8	84°3	78°9	78°1	78°2	73°5	65°6	60°2	72°9
6	54°2	60°7	73°5	81°0	84°0	84°0	78°6	78°3	77°8	72°7	64°7	59°4	72°4
7	53°4	60°3	72°9	81°7	85°0	84°8	79°4	78°6	78°2	72°7	64°2	58°8	72°5
8	52°9	61°5	75°3	84°3	88°5	86°3	80°5	79°7	80°1	73°8	64°5	59°2	73°9
9	55°3	63°7	79°0	87°8	92°3	88°4	81°7	80°8	81°7	77°0	68°5	61°9	76°5
10	59°2	66°6	83°7	91°1	95°2	90°5	83°2	81°6	83°1	79°7	71°8	66°7	79°4
11	62°1	69°1	85°2	93°7	97°0	92°8	84°5	82°5	84°3	81°8	74°1	70°1	81°4
12	63°9	71°1	87°3	96°7	98°8	94°6	85°5	83°3	85°5	83°4	76°4	71°6	83°2
13	65°3	72°8	88°7	98°1	99°8	95°9	85°8	84°0	86°4	84°5	77°5	72°6	84°3
14	66°0	74°0	89°9	99°4	100°4	97°2	86°0	84°0	87°1	85°5	78°3	73°3	85°1
15	66°6	75°3	90°7	100°1	101°0	97°8	85°6	83°8	87°5	85°8	78°3	73°8	85°5
16	66°5	75°7	91°2	100°7	100°4	97°8	84°6	83°2	87°5	85°7	77°9	73°9	85°4
17	65°8	75°7	90°8	100°1	99°5	96°1	83°5	82°7	86°9	84°9	76°4	72°9	84°6
18	64°8	74°2	88°8	98°5	98°1	94°3	82°9	82°1	86°0	83°5	75°6	71°8	83°4
19	64°0	73°1	87°0	96°9	96°9	93°2	82°5	81°5	85°1	82°8	75°0	70°9	82°4
20	63°3	71°9	85°9	95°5	95°9	91°8	82°2	80°7	84°0	82°2	74°4	69°9	81°5
21	62°5	70°4	84°6	94°2	94°8	90°9	81°9	80°4	83°1	81°6	73°8	69°0	80°6
22	61°6	68°7	83°4	92°0	93°5	90°1	81°6	79°9	82°1	80°0	73°2	68°0	79°5
23	60°6	67°2	82°4	90°0	92°0	89°2	81°3	79°4	81°4	79°2	72°3	67°0	78°5
Mean	60°5	68°0	81°8	91°3	93°1	90°5	82°1	81°2	82°7	79°7	72°0	67°0	79°2

The five sections of Table II are only fairly comparable as regards the two pairs, B and C, and D and E. These pairs are not intercomparable, because the exposures of the thermometers were different, and the observations of the former covered two years, whilst those of the latter extended only over one. The daily range in the shed is apparently so much greater than in either of the other methods of exposure that the first section is not comparable with any of the others. To reduce these observations made under different conditions to a common basis, I have made use of the following assumptions:—

(1) That in Table II the departure of the temperature of any given hour from the daily mean is a function of the height, expressible by the equation, $\delta = \delta_0 + ah + bh^2$

(2) That variations of exposure which alter the daily range of temperature affect only the term δ_0 of this formula, or that the constants a and b , though varying from hour to hour and month to month, are the same for all three kinds of exposure.

There is no justification for the second assumption except that some such supposition is necessary, and that it seems to give results which are consistent and probably not far from the truth.

Taking two pairs of variations for a certain hour from Table II, B and C, and Table II, C and D, respectively, and denoting the heights, measured from 4 feet above the ground, by h_1 and h_2 , h_3 and h_4 , we have the equations:—

$$\begin{aligned}\delta_1 &= \delta_0' + a h_1 + b h_1^2 \\ \delta_2 &= \delta_0' + a h_2 + b h_2^2 \\ \delta_3 &= \delta_0'' + a h_3 + b h_3^2 \\ \delta_4 &= \delta_0'' + a h_4 + b h_4^2\end{aligned}$$

Subtracting we get—

$$\begin{aligned}\delta_1 - \delta_2 &= a (h_1 - h_2) + b (h_1^2 - h_2^2) \\ \delta_3 - \delta_4 &= a (h_3 - h_4) + b (h_3^2 - h_4^2)\end{aligned}$$

These two equations suffice to determine a and b , and for δ_0 in the formula adopted for computation, I have taken in each case the variation given by the standard observations under the shed. Thus for the month of April, the temperatures given in Table II are:—

	Shed.	6 ft.	46 ft.	104 ft.	166 ft.
14 H. . . .	102.4°	100.6°	99.3°	100.0°	99.4°
Daily Mean . .	87.9	87.8	88.8	91.1	91.3
Variation at 14 H. .	+14.5	+12.8	+10.5	+8.9	+8.1

Combining the four tower observations as above, we get:—

$$\begin{aligned}12.8 - 10.5 &= a(2 - 42) + b(2^2 - 42^2) \\ 8.9 - 8.1 &= a(100 - 162) + b(100^2 - 162^2) \\ \text{These equations give us } a &= -.0663 \\ b &= +.0002\end{aligned}$$

Combining these with $\delta_0 = +14.5^\circ$, we find as the resulting normal variations the following:—

6 ft.	46 ft.	104 ft.	166 ft.
14.4°	12.1	+9.9	+9.1

These are the values given in Table III.

Computed values have in this way been determined for every month at 6, 14 and 22 hours, and the variations at the intermediate hours have been interpolated as described in page 365. The only instance in which the computed variations have been rejected as improbable is that of the 6 A.M. observations of the month of February. In this instance both $\delta_1 - \delta_2$ and $\delta_3 - \delta_4$ are small, each being equal to 0.6° , while $\delta_2 - \delta_3$ is 2.3° , or nearly four times as great. Consequently the deduced values of δ come out much too great at great elevations. Instead of the values computed by the formula for this particular case, others have been obtained by interpolation from a curve intermediate in form between those for January and March at 6 A.M.

The diurnal variations of temperature at four different heights above the ground, thus computed on the assumption that the exposure of the thermometers is in each case similar to that under the standard shed, are given in Table III. The variations at the height of 6 feet have been omitted, as in most months they do not differ at any hour by more than a tenth of a degree from those observed at 4 feet.

TABLE III A.—Normal diurnal variation of temperature at the height of 4 feet.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
0	4.6	6.7	7.9	7.5	6.0	4.6	2.8	2.7	4.0	5.4	6.8	6.2	5.4
1	5.7	7.8	9.5	9.3	7.1	5.7	3.1	2.9	4.6	5.9	7.7	7.3	6.4
2	6.6	8.8	11.0	11.1	8.3	6.6	3.4	3.1	5.0	6.5	8.5	8.3	7.3
3	7.4	9.9	12.2	12.4	9.4	7.2	3.7	3.3	5.4	7.0	9.2	9.2	8.0
4	8.1	10.8	13.1	13.7	10.4	7.8	3.9	3.5	5.7	7.4	10.0	10.0	8.7
5	8.7	11.6	14.0	14.5	11.4	8.1	4.0	3.7	5.9	7.7	10.7	10.6	9.2
6	9.1	12.2	14.7	14.7	11.4	7.8	3.7	3.7	5.7	7.6	11.4	11.0	9.4
7	9.0	11.2	12.4	11.5	8.6	5.3	2.5	2.7	3.2	5.5	9.1	11.4	7.6
8	5.2	5.9	4.4	5.1	4.0	2.1	0.7	1.1	0.9	1.3	2.9	6.1	3.3
9	0.4	+ 0.3	+ 1.2	+ 1.1	- 0.1	+ 0.5	+ 0.4	+ 0.4	+ 1.3	+ 2.1	+ 2.9	+ 0.5	+ 0.8
10	+ 3.2	+ 4.3	+ 5.7	+ 6.1	+ 4.1	+ 2.7	+ 1.6	+ 1.7	+ 2.8	+ 4.6	+ 7.1	+ 5.2	+ 4.1
11	+ 6.1	+ 7.6	+ 9.0	+ 9.6	+ 6.8	+ 4.8	+ 3.3	+ 3.0	+ 4.9	+ 6.7	+ 10.0	+ 9.0	+ 6.7
12	+ 8.8	+ 10.5	+ 11.6	+ 12.1	+ 9.0	+ 6.3	+ 4.5	+ 4.2	+ 6.5	+ 8.5	+ 11.7	+ 11.8	+ 8.8
13	+ 9.9	+ 12.0	+ 13.8	+ 13.6	+ 10.7	+ 7.8	+ 5.2	+ 4.6	+ 8.1	+ 9.5	+ 13.1	+ 13.1	+ 10.1
14	+ 10.8	+ 13.2	+ 15.2	+ 14.5	+ 11.6	+ 8.8	+ 5.5	+ 4.9	+ 8.6	+ 10.3	+ 14.0	+ 14.1	+ 11.0
15	+ 11.4	+ 14.0	+ 15.4	+ 14.7	+ 12.1	+ 9.3	+ 5.2	+ 4.4	+ 8.2	+ 10.3	+ 14.5	+ 14.4	+ 11.2
16	+ 11.0	+ 13.7	+ 14.9	+ 14.3	+ 11.3	+ 8.1	+ 4.1	+ 3.8	+ 5.5	+ 9.3	+ 13.4	+ 13.3	+ 10.2
17	+ 9.0	+ 12.1	+ 13.0	+ 13.2	+ 9.7	+ 6.7	+ 2.5	+ 3.0	+ 3.4	+ 6.3	+ 7.9	+ 9.9	+ 8.1
18	+ 3.9	+ 7.3	+ 8.3	+ 9.5	+ 7.5	+ 4.8	+ 1.2	+ 1.9	+ 1.3	+ 1.0	+ 1.2	+ 2.2	+ 4.2
19	+ 1.6	+ 2.6	+ 3.3	+ 3.7	+ 3.7	+ 2.6	+ 0.3	+ 0.5	- 0.6	- 0.8	- 0.8	0	+ 1.3
20	- 0.2	0	+ 0.1	+ 0.2	+ 0.9	+ 0.2	- 0.6	- 0.6	- 1.2	- 1.9	- 3.0	- 1.9	- 0.7
21	- 2.0	- 2.4	- 2.2	- 2.1	- 1.9	- 1.4	- 1.3	- 1.4	- 2.2	- 3.0	- 4.3	- 3.0	- 2.3
22	- 3.4	- 4.2	- 4.4	- 4.6	- 3.4	- 2.4	- 1.9	- 1.9	- 3.0	- 4.0	- 5.1	- 4.1	- 3.5
23	- 4.2	- 5.5	- 6.6	- 6.1	- 4.9	- 3.5	- 2.4	- 2.3	- 3.5	- 4.8	- 5.9	- 5.1	- 4.6

TABLE III C.—Normal diurnal variation of temperature at the height of 46 feet.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
0	3.6	4.7	5.1	5.4	4.9	3.7	2.3	2.6	3.3	4.1	4.5	4.5	4.1
1	4.6	5.9	6.6	7.2	6.4	4.7	2.8	2.9	3.9	5.0	5.8	6.0	5.2
2	5.4	7.1	8.1	9.1	7.9	5.5	3.3	3.2	4.4	5.8	7.2	7.5	6.3
3	6.3	8.2	9.5	10.6	8.9	6.2	3.6	3.5	5.0	6.4	8.5	8.6	7.2
4	7.1	9.2	11.0	11.8	9.8	6.9	4.0	3.6	5.5	7.0	9.8	9.6	8.0
5	8.0	10.2	12.4	13.0	10.5	7.6	4.0	3.7	5.9	7.6	10.8	10.5	8.7
6	8.8	10.9	13.4	13.5	10.7	7.4	3.5	3.6	6.1	7.9	11.6	11.3	9.1
7	8.5	10.2	11.3	11.8	10.4	5.5	2.3	2.5	3.9	6.2	10.5	11.4	7.9

TABLE III C.—Normal diurnal variation of temperature at the height of 46 feet—continued.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
8	- 5'3	- 6'2	- 6'3	- 6'4	- 4'8	- 3'2	- 0'9	- 0'8	- 1'2	- 2'9	- 6'5	- 7'6	- 4'4
9	- 2'0	- 1'8	- 1'7	- 1'2	- 1'2	- 1'1	+ 0'5	+ 0'8	+ 1'0	+ 0'3	- 2'5	- 2'6	- 1'0
10	+ 1'0	+ 1'6	+ 2'2	+ 3'1	+ 2'3	+ 1'0	+ 1'8	+ 1'8	+ 2'9	+ 3'1	+ 2'8	+ 2'0	+ 2'1
11	+ 4'0	+ 5'0	+ 5'3	+ 6'6	+ 4'9	+ 3'0	+ 3'1	+ 2'8	+ 4'5	+ 5'3	+ 5'9	+ 5'8	+ 4'6
12	+ 6'5	+ 7'7	+ 8'4	+ 8'9	+ 7'0	+ 4'6	+ 4'3	+ 3'6	+ 5'9	+ 7'0	+ 8'5	+ 8'6	+ 6'7
13	+ 8'1	+ 9'6	+ 10'8	+ 10'8	+ 8'8	+ 6'0	+ 4'8	+ 4'0	+ 7'3	+ 8'4	+ 10'3	+ 10'5	+ 8'2
14	+ 9'3	+ 11'4	+ 12'8	+ 12'1	+ 10'3	+ 7'4	+ 5'0	+ 4'2	+ 8'0	+ 9'2	+ 11'9	+ 11'8	+ 9'4
15	+ 9'3	+ 11'9	+ 13'1	+ 12'9	+ 10'8	+ 8'0	+ 4'6	+ 4'2	+ 6'6	+ 8'8	+ 11'8	+ 11'9	+ 9'5
16	+ 8'8	+ 11'3	+ 13'1	+ 13'1	+ 10'7	+ 7'9	+ 3'2	+ 3'9	+ 4'1	+ 7'7	+ 11'0	+ 11'2	+ 8'8
17	+ 7'5	+ 9'8	+ 11'6	+ 11'5	+ 9'6	+ 6'7	+ 2'1	+ 3'4	+ 2'9	+ 5'8	+ 8'6	+ 9'2	+ 7'3
18	+ 5'2	+ 6'7	+ 8'3	+ 8'8	+ 7'7	+ 5'4	+ 1'2	+ 2'3	+ 1'8	+ 3'0	+ 5'8	+ 6'3	+ 5'1
19	+ 3'5	+ 3'8	+ 4'8	+ 4'5	+ 4'9	+ 3'7	+ 0'3	+ 0'4	+ 0'7	+ 1'5	+ 3'9	+ 4'1	+ 2'9
20	+ 1'7	+ 1'4	+ 1'5	+ 2'0	+ 2'5	+ 1'8	- 0'3	- 0'4	- 0'2	+ 0'1	+ 1'9	+ 2'1	+ 1'1
21	+ 0'0	- 0'7	- 0'5	0'0	+ 0'5	+ 0'2	- 0'8	- 1'2	- 1'2	- 1'3	+ 0'2	+ 0'3	- 0'4
22	- 1'6	- 2'4	- 2'2	- 2'0	- 1'5	- 1'3	- 1'3	- 1'8	- 2'1	- 2'6	- 1'7	- 1'5	- 1'9
23	- 2'6	- 3'5	- 3'5	- 3'6	- 3'2	- 2'6	- 1'8	- 2'2	- 2'7	- 3'5	- 3'1	- 3'0	- 3'0

TABLE III D.—Normal diurnal variation of temperature at the height of 104 feet.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
0	- 2'5	- 4'1	- 3'3	- 3'8	- 3'2	- 2'4	- 1'6	- 1'7	- 3'3	- 3'4	- 2'1	- 2'5	- 2'8
1	- 3'6	- 5'1	- 4'9	- 5'5	- 4'8	- 3'4	- 2'1	- 2'0	- 4'1	- 4'6	- 3'8	- 4'0	- 3'9
2	- 4'6	- 6'1	- 6'6	- 7'0	- 6'3	- 4'3	- 2'5	- 2'3	- 4'8	- 5'6	- 5'5	- 5'5	- 5'0
3	- 5'6	- 7'0	- 8'2	- 8'5	- 7'8	- 5'2	- 2'9	- 2'6	- 5'4	- 6'5	- 7'2	- 6'9	- 6'1
4	- 6'6	- 7'8	- 9'7	- 9'9	- 9'1	- 6'1	- 3'4	- 2'9	- 5'9	- 7'0	- 8'9	- 8'3	- 7'1
5	- 7'5	- 8'7	- 10'8	- 11'2	- 9'8	- 6'6	- 3'7	- 3'2	- 6'4	- 7'6	- 10'6	- 9'7	- 7'9
6	- 8'5	- 9'4	- 11'9	- 12'5	- 10'2	- 6'8	- 3'6	- 3'0	- 6'9	- 8'0	- 11'5	- 11'1	- 8'6
7	- 9'2	- 9'5	- 11'9	- 11'3	- 8'6	- 5'8	- 2'6	- 2'8	- 5'7	- 7'5	- 10'9	- 11'5	- 8'1
8	- 8'6	- 8'1	- 7'9	- 7'7	- 4'9	- 4'2	- 1'5	- 1'5	- 3'2	- 5'2	- 9'0	- 9'2	- 5'9
9	- 4'0	- 4'4	- 3'9	- 2'9	- 0'6	- 2'4	- 0'1	- 0'0	- 0'7	- 1'7	- 3'7	- 4'1	- 2'3
10	+ 0'4	- 0'2	+ 0'4	+ 0'9	+ 2'3	- 0'1	+ 1'3	+ 1'6	+ 1'6	+ 2'1	+ 1'0	+ 0'7	+ 1'1
11	+ 3'3	+ 3'6	+ 3'7	+ 3'8	+ 4'9	+ 1'8	+ 2'5	+ 2'8	+ 3'2	+ 4'3	+ 3'9	+ 4'2	+ 3'6
12	+ 5'3	+ 5'8	+ 6'6	+ 6'3	+ 6'5	+ 3'8	+ 3'4	+ 3'6	+ 4'7	+ 5'8	+ 6'4	+ 6'5	+ 5'5
13	+ 6'7	+ 8'0	+ 8'9	+ 8'6	+ 7'9	+ 5'4	+ 4'1	+ 4'2	+ 6'1	+ 7'1	+ 8'5	+ 8'1	+ 7'0
14	+ 7'9	+ 9'7	+ 10'3	+ 9'9	+ 8'9	+ 6'5	+ 4'3	+ 4'2	+ 7'0	+ 8'1	+ 9'8	+ 9'5	+ 8'1
15	+ 8'4	+ 10'1	+ 10'8	+ 10'8	+ 9'3	+ 7'5	+ 3'9	+ 3'1	+ 7'0	+ 8'0	+ 9'4	+ 9'7	+ 8'2

TABLE III D.—Normal diurnal variation of temperature at the height of 104 feet—continued.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
16	+ 8.3	+ 9.9	+ 10.9	+ 11.3	+ 8.8	+ 7.9	+ 3.4	+ 2.5	+ 6.9	+ 7.5	+ 8.5	+ 9.2	+ 8.0
17	+ 7.3	+ 9.0	+ 10.2	+ 10.3	+ 8.1	+ 6.2	+ 2.2	+ 1.8	+ 5.8	+ 6.3	+ 7.3	+ 7.7	+ 6.0
18	+ 6.0	+ 7.2	+ 7.5	+ 8.3	+ 6.2	+ 4.1	+ 1.1	+ 1.2	+ 4.1	+ 5.2	+ 6.1	+ 6.5	+ 5.3
19	+ 4.7	+ 5.4	+ 5.6	+ 5.8	+ 4.3	+ 2.7	+ 0.6	+ 0.6	+ 2.7	+ 3.6	+ 5.0	+ 5.0	+ 3.9
20	+ 2.9	+ 3.3	+ 3.7	+ 3.9	+ 2.3	+ 1.6	+ 0.1	8.0	+ 1.4	+ 2.2	+ 3.7	+ 3.5	+ 2.4
21	+ 1.3	+ 1.4	+ 1.8	+ 2.4	+ 1.2	+ 0.7	+ 0.4	+ 0.5	+ 0.0	+ 0.7	+ 2.5	+ 2.1	+ 1.2
22	+ 0.2	+ 1.0	0.0	+ 0.1	+ 0.1	+ 0.2	+ 0.8	+ 0.9	+ 1.5	+ 1.1	+ 1.3	+ 0.6	+ 0.3
23	+ 1.3	+ 2.8	+ 1.6	+ 2.0	+ 1.6	+ 1.3	+ 1.2	+ 1.3	+ 2.6	+ 2.4	+ 0.4	+ 1.0	+ 1.6

TABLE III E.—Normal diurnal variation of temperature at the height of 166 feet.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
0	+ 1.9	+ 3.6	+ 2.5	+ 3.3	+ 3.0	+ 1.9	+ 1.2	+ 2.0	+ 2.8	+ 2.7	+ 0.5	+ 1.7	+ 2.2
1	+ 2.9	+ 4.8	+ 4.1	+ 5.1	+ 4.7	+ 3.0	+ 1.7	+ 2.3	+ 3.6	+ 3.5	+ 2.5	+ 3.2	+ 3.4
2	+ 3.9	+ 5.8	+ 5.7	+ 6.4	+ 5.4	+ 4.1	+ 2.2	+ 2.6	+ 4.3	+ 4.3	+ 4.4	+ 4.7	+ 4.5
3	+ 4.9	+ 6.7	+ 7.0	+ 7.8	+ 8.1	+ 5.1	+ 2.6	+ 2.9	+ 5.0	+ 5.2	+ 6.2	+ 6.2	+ 5.6
4	+ 5.8	+ 7.6	+ 8.1	+ 9.3	+ 9.5	+ 5.8	+ 3.0	+ 3.0	+ 5.6	+ 6.0	+ 7.9	+ 7.6	+ 6.6
5	+ 6.7	+ 8.2	+ 9.1	+ 10.3	+ 10.1	+ 6.3	+ 3.4	+ 3.1	+ 6.2	+ 6.8	+ 9.4	+ 8.9	+ 7.4
6	+ 7.5	+ 8.4	+ 10.1	+ 11.2	+ 10.0	+ 6.7	+ 3.7	+ 3.0	+ 6.7	+ 7.5	+ 10.8	+ 10.0	+ 8.0
7	+ 7.9	+ 8.3	+ 10.4	+ 10.2	+ 8.8	+ 5.9	+ 2.9	+ 2.6	+ 5.8	+ 7.2	+ 10.6	+ 10.0	+ 7.5
8	+ 8.0	+ 6.7	+ 7.8	+ 7.4	+ 5.0	+ 4.4	+ 1.7	+ 1.3	+ 3.3	+ 5.8	+ 9.5	+ 9.0	+ 5.8
9	+ 5.2	+ 4.0	+ 3.8	+ 3.6	+ 1.0	+ 2.4	+ 0.5	+ 0.1	+ 1.2	+ 2.3	+ 4.7	+ 5.7	+ 2.9
10	+ 0.8	+ 0.6	+ 0.2	+ 0.1	+ 2.2	+ 0.3	+ 1.1	+ 0.9	+ 0.7	+ 0.8	+ 0.3	+ 0.3	+ 0.4
11	+ 2.5	+ 2.4	+ 2.9	+ 2.8	+ 4.2	+ 2.0	+ 2.4	+ 1.9	+ 2.5	+ 3.2	+ 2.5	+ 3.6	+ 2.8
12	+ 4.7	+ 4.9	+ 5.3	+ 6.1	+ 6.3	+ 3.7	+ 3.5	+ 2.9	+ 4.2	+ 5.1	+ 5.6	+ 5.7	+ 4.8
13	+ 6.5	+ 7.0	+ 6.9	+ 7.6	+ 7.5	+ 5.0	+ 3.8	+ 3.8	+ 5.7	+ 6.5	+ 7.5	+ 7.3	+ 6.3
14	+ 7.6	+ 8.7	+ 8.4	+ 9.1	+ 8.4	+ 6.3	+ 4.1	+ 4.0	+ 6.9	+ 7.8	+ 9.1	+ 8.6	+ 7.4
15	+ 7.9	+ 9.5	+ 9.0	+ 9.7	+ 8.9	+ 7.0	+ 3.7	+ 3.7	+ 6.9	+ 7.7	+ 8.8	+ 8.8	+ 7.7
16	+ 7.4	+ 9.3	+ 9.4	+ 10.3	+ 8.1	+ 7.2	+ 2.7	+ 3.0	+ 6.6	+ 7.2	+ 8.2	+ 8.6	+ 7.4
17	+ 6.3	+ 8.8	+ 8.8	+ 9.5	+ 7.1	+ 5.6	+ 1.5	+ 2.4	+ 5.6	+ 6.0	+ 6.4	+ 7.3	+ 6.3
18	+ 5.0	+ 6.7	+ 6.7	+ 7.7	+ 5.5	+ 3.9	+ 0.9	+ 1.7	+ 3.3	+ 4.3	+ 5.3	+ 6.0	+ 4.8
19	+ 3.8	+ 5.1	+ 4.7	+ 5.9	+ 4.2	+ 2.9	+ 0.5	+ 1.1	+ 3.9	+ 3.2	+ 4.5	+ 4.8	+ 3.7
20	+ 2.7	+ 3.3	+ 3.5	+ 4.3	+ 3.0	+ 1.7	+ 0.1	+ 1.1	+ 1.6	+ 1.9	+ 3.6	+ 3.5	+ 2.5
21	+ 1.5	+ 1.3	+ 2.0	+ 2.9	+ 1.8	+ 0.9	+ 0.2	+ 0.2	+ 0.3	+ 0.6	+ 2.8	+ 2.3	+ 1.4
22	+ 0.2	+ 1.0	+ 0.7	+ 0.5	+ 0.3	+ 0.2	+ 0.5	+ 0.8	+ 1.1	+ 0.7	+ 1.7	+ 1.0	+ 0.1
23	+ 0.8	+ 2.4	+ 0.8	+ 1.6	+ 1.3	+ 0.8	+ 0.8	+ 1.4	+ 1.9	+ 1.8	+ 0.5	+ 0.3	+ 1.1

The variation of the mean temperature with elevation above the ground might be computed in a manner similar to that adopted for the departure from the mean at any hour, but another and perhaps more orthodox method is in this case applicable, since the exposures of the thermometers, though sufficiently unlike to affect the diurnal variation to a very appreciable extent, are all good enough to give true monthly means. The means given in Table I have been computed from the crude means of the observation at fixed hours by the aid of corrections deduced from the hourly values in Table II, and in each case they may be accepted as true mean temperatures for the period of observation. They may be reduced to normal values, and thereby rendered comparable, by adding to the normal monthly means at 4 feet from the ground the differences between the monthly means of B, C, D or E, Table I, and those of Table I A for the same period, the normal values themselves being taken for the height of 4 feet, instead of those given under Table I A. As normal values for the temperature of Allahabad I have adopted the means of the 22 years, 1866—87 inclusive, due allowance having been made for all differences introduced by changes in the site of the observatory. In this way the normal monthly means at the different elevations, given in Table IV, have been found.

TABLE IV.—*Normal mean temperatures.*

Height.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
4 Feet .	60.5	65.3	77.5	87.1	91.7	91.2	84.9	83.7	83.4	78.0	67.6	60.1	77.6
6 „ .	60.0	65.8	77.8	87.0	91.4	91.3	84.7	83.8	83.0	78.2	67.3	59.7	77.4
46 „ .	61.6	67.5	79.5	87.3	91.1	90.6	84.1	83.3	82.9	79.3	69.9	62.1	78.2
104 „ .	63.2	66.8	80.0	88.9	91.3	89.0	83.3	82.4	83.1	80.0	71.1	64.3	78.7
166 „ .	63.5	67.4	79.7	89.1	91.3	88.8	83.1	82.7	83.2	80.7	71.9	65.4	79.0

From Table IV it appears probable that, owing to the thermograph pent-house being attached, as above stated, to the north wall of a building of considerable size, which for several hours each day, especially in the winter season, keeps the ground near it in the shade, the mean temperature at 6 feet is 0.2° or 0.3° too low, and should be rejected, especially as we have true normal values for each month derived from observations made in the shed at very nearly the same height. The other figures exhibit in some months slight irregularities, not exceeding 0.3° in any month except February, when there is an apparent decrease of 0.7° between 46 and 104 feet, though on the whole the temperature increases slightly with distance from the ground. It is probably fair to assume that these slight departures from a regular variation would disappear if the period of observation were extended, and on this assumption I have laid off the figures in Table IV on section paper, and through and between the points marked have drawn freehand curves of approximately parabolic form, where a straight line did not appear to suit, from which curves the temperatures entered in Table V have been read off.

TABLE V.—*Monthly mean temperatures interpolated for various elevations.*

Elev.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
	°	°	°	°	°	°	°	°	°	°	°	°	°
0	60.3	65.2	77.4	87.0	91.7	91.3	85.0	83.8	83.4	77.9	67.5	59.9	77.5
10	60.7	65.6	77.9	87.3	91.6	91.1	84.8	83.6	83.3	78.3	68.0	60.5	77.7

TABLE V.—*Monthly mean temperatures interpolated for various elevations—continued.*

FEET.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
20	61.0	66.0	78.3	87.5	91.6	90.8	84.6	83.4	83.2	78.6	68.5	61.1	77.8
30	61.3	66.3	78.7	87.7	91.5	90.6	84.4	83.3	83.2	78.9	69.0	61.6	78.0
40	61.6	66.6	79.0	87.9	91.5	90.4	84.2	83.1	83.1	79.2	69.4	62.1	78.2
50	61.9	66.9	79.3	88.1	91.4	90.2	84.0	83.0	83.1	79.4	69.7	62.5	78.3
60	62.2	67.1	79.6	88.3	91.4	90.0	83.9	82.9	83.1	79.6	70.0	62.9	78.4
70	62.4	67.3	79.8	88.5	91.3	89.9	83.7	82.8	83.0	79.8	70.4	63.3	78.5
80	62.6	67.5	79.9	88.6	91.3	89.7	83.6	82.7	83.0	80.0	70.7	63.6	78.6
90	62.8	67.6	80.0	88.7	91.3	89.6	83.5	82.6	83.0	80.2	71.0	63.9	78.7
100	62.9	67.7	80.1	88.8	91.2	89.4	83.4	82.6	83.0	80.3	71.2	64.2	78.7
110	63.1	67.8	80.2	88.9	91.2	89.3	83.3	82.6	83.0	80.4	71.4	64.5	78.8
120	63.2	67.8	80.1	89.0	91.2	89.2	83.2	82.6	83.0	80.5	71.5	64.7	78.8
130	63.3	67.8	80.1	89.1	91.2	89.1	83.2	82.6	83.0	80.5	71.6	64.9	78.9
140	63.4	67.8	80.0	89.1	91.1	89.0	83.1	82.6	83.0	80.5	71.7	65.1	78.9
150	63.5	67.7	79.8	89.1	91.1	88.9	83.1	82.6	83.1	80.5	71.8	65.2	78.9
160	63.6	67.6	79.6	89.0	91.1	88.8	83.1	82.7	83.1	80.5	71.8	65.2	78.9
170	63.6	67.5	79.4	88.9	91.1	88.7	83.1	82.7	83.1	80.5	71.8	65.3	78.9
180	63.6	67.3	79.1	88.8	91.1	88.7	83.1	82.8	83.1	80.4	71.7	65.3	78.9
190	63.6	67.1	78.8	88.7	91.1	88.6	83.2	82.9	83.2	80.3	71.7	65.3	78.8
200	63.6	66.8	78.4	88.6	91.1	88.6	83.2	83.1	83.2	80.2	71.6	65.3	78.8

It will be observed that the mean temperature diminishes normally from the ground upwards only in May and June, which are the hottest months and also those of greatest wind velocity. During the rainy months, July, August and September, there is a normal decrease of temperature up almost to the highest of the four points at which observations were made, but there are indications of a slight increase at still higher elevations. The reason of any such increase is difficult to see, and it may be regarded as doubtful. In December and January the temperature *increases* up to and beyond the highest of the tower cages, but more and more slowly as the height increases, and in all the remaining months there is an increase up to a certain point, above which the normal decrease sets in. In all the months from October to April inclusive, the nights are calm as a rule, and the air which is cooled by radiation, or by contact with cold objects, sinks and remains near the ground; while in the day-time the temperature gradient in the opposite direction, which would probably overbalance the nocturnal variation, as regards the mean of the 24 hours, were the conditions otherwise the same, is diminished by the mixing up of different strata by the movement of the wind, which attains its maximum velocity about the hottest time of the day.

On the average of the whole year the temperature increases up to about 155 feet from the ground, and the increase amounts to about $1\frac{1}{2}^{\circ}$.

This peculiarity of the distribution of temperature at moderate elevations above the

ground has not been taken into account, so far as I am aware, by any writer on the barometric measurement of heights, the temperature of the air being always taken for this purpose from observations made at or about the standard height of four feet, which in India and countries with similar climates, must as a rule give values below the truth. For small differences of level the resulting error in the barometrically determined elevation will be negligible, but for differences over 1,000 feet the peculiarity mentioned must have a perceptible effect on the result.

The mean temperatures in Table V, together with the variations from the mean in Table III, enable us to calculate the normal temperature of every hour at each of the four different levels where observations have been made. Table VI gives these computed normal temperatures.

TABLE VI A.—Normal hourly temperatures at the height of 4 feet.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
0	55.9	58.6	69.6	79.6	85.7	86.6	82.1	81.0	79.4	72.6	60.8	53.9	72.2
1	54.8	57.5	68.0	77.8	84.6	85.5	81.8	80.8	78.8	72.1	59.9	52.8	71.2
2	53.9	56.5	66.5	76.0	83.4	84.6	81.5	80.6	78.4	71.5	59.1	51.8	70.3
3	53.1	55.4	65.3	74.7	82.3	84.0	81.2	80.4	78.0	71.0	58.4	50.9	69.6
4	52.4	54.5	64.4	73.4	81.3	83.4	81.0	80.2	77.7	70.6	57.6	50.1	68.9
5	51.8	53.7	63.5	72.6	80.3	83.1	80.9	80.0	77.5	70.3	56.9	49.5	68.4
6	51.4	53.1	62.8	72.4	80.3	83.4	81.2	80.0	77.7	70.4	56.2	49.1	68.2
7	51.5	54.1	65.1	75.6	83.7	85.9	82.4	81.0	80.2	72.5	58.5	48.7	70.0
8	55.3	59.4	73.1	82.0	87.7	89.1	84.2	82.6	82.5	76.7	64.7	54.0	74.3
9	60.1	65.6	78.7	88.2	91.6	91.7	85.3	84.1	84.7	80.1	70.5	60.6	78.4
10	63.7	69.6	83.2	93.2	95.8	93.9	86.5	85.4	86.2	82.6	74.7	65.3	81.7
11	66.6	72.9	86.5	96.7	98.5	96.0	88.2	86.7	88.3	84.7	77.6	69.1	84.3
12	69.3	75.8	89.1	99.2	100.7	97.5	89.4	87.9	89.9	86.5	79.3	71.9	86.4
13	70.4	77.3	91.3	100.7	102.4	99.0	90.1	88.3	91.5	87.5	80.7	73.2	87.7
14	71.3	78.5	92.7	101.6	103.3	100.0	90.4	88.6	92.0	88.3	81.6	74.2	88.6
15	71.9	79.3	92.9	101.8	103.8	100.5	90.1	88.1	91.6	88.3	82.1	74.5	88.8
16	71.5	79.0	92.4	101.4	103.0	99.3	89.0	87.5	88.9	87.3	81.9	73.4	87.8
17	69.5	77.4	90.5	100.3	101.4	97.9	87.4	86.7	86.8	84.3	75.5	70.0	85.7
18	64.4	72.6	85.8	96.6	99.2	96.0	86.1	85.6	84.7	79.0	68.8	62.3	81.8
19	62.1	67.9	80.8	90.8	95.4	93.8	85.2	84.2	82.8	77.2	66.8	60.1	78.9
20	60.3	65.3	77.6	87.3	92.6	91.4	84.3	83.1	82.2	76.1	64.6	58.2	76.9
21	58.5	62.9	75.3	85.0	89.3	89.8	83.6	82.3	81.2	75.0	63.3	57.1	75.3
22	57.1	61.1	73.1	82.5	88.3	88.8	83.0	81.8	80.4	74.0	62.5	56.0	74.1
23	56.3	59.8	70.9	81.0	86.8	87.7	82.5	81.4	79.9	73.2	61.7	55.0	73.0
Mean	60.5	65.3	77.5	87.1	91.7	91.2	84.9	83.7	83.4	78.0	67.6	60.1	77.6

TABLE VI C.—*Normal hourly temperatures at the height of 46 feet.*

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
0	58.2	62.1	74.1	82.6	86.5	86.6	81.8	80.4	79.8	75.2	65.1	57.8	74.2
1	57.2	60.9	72.6	80.8	85.0	85.6	81.3	80.1	79.2	74.3	63.8	56.3	73.1
2	56.4	59.7	71.1	78.9	83.5	84.8	80.8	79.8	78.7	73.5	62.4	54.8	72.0
3	55.5	58.6	69.7	77.4	82.5	84.1	80.5	79.5	78.1	72.9	61.1	53.7	71.1
4	54.7	57.6	68.2	76.2	81.6	83.4	80.1	79.4	77.6	72.3	59.8	52.7	70.3
5	53.8	56.6	66.8	75.0	80.9	82.7	80.1	79.3	77.2	71.7	58.8	51.8	69.6
6	53.0	55.9	65.8	74.5	80.7	82.9	80.6	79.4	77.0	71.4	58.0	51.0	69.2
7	53.3	56.6	67.9	76.2	81.0	84.8	81.8	80.5	79.2	73.1	59.1	50.9	70.4
8	56.5	60.6	72.9	81.6	86.6	87.1	83.2	82.2	81.9	76.4	63.1	54.7	73.9
9	59.8	65.0	77.5	86.8	90.2	89.2	84.6	83.8	84.1	79.6	67.1	59.7	77.3
10	62.8	68.4	81.4	91.1	93.7	91.3	85.9	84.8	86.0	82.4	72.4	64.3	80.4
11	65.8	71.8	84.5	94.6	96.3	93.3	87.2	85.8	87.6	84.6	75.5	68.1	82.9
12	68.3	74.5	87.6	96.9	98.4	94.9	88.4	86.6	89.0	86.3	78.1	70.9	85.0
13	69.9	76.4	90.0	98.7	100.2	96.3	88.9	87.0	90.4	87.7	79.9	72.8	86.5
14	71.1	78.2	92.0	100.1	101.7	97.7	89.1	87.2	91.1	88.5	81.5	74.1	87.7
15	71.1	78.7	92.3	100.9	102.2	98.3	88.7	87.2	89.7	88.1	81.4	74.2	87.8
16	70.6	78.1	92.3	101.1	102.4	98.2	87.3	86.9	87.2	87.0	80.6	73.5	87.1
17	69.3	76.6	90.8	99.5	101.0	97.0	86.2	86.4	86.0	85.1	78.2	71.5	85.6
18	67.0	73.5	87.5	96.8	99.1	95.7	85.3	85.3	84.9	82.3	75.4	68.6	83.4
19	65.3	70.6	84.0	92.5	96.3	94.0	84.4	83.4	83.8	80.8	73.5	66.4	81.2
20	63.5	68.2	80.7	90.0	93.9	92.1	83.8	82.6	82.9	79.4	71.5	64.4	79.4
21	61.8	66.1	78.7	88.0	91.9	90.5	83.3	81.8	81.9	78.0	69.8	62.6	77.9
22	60.2	64.4	77.0	86.0	89.9	89.0	82.8	81.2	81.0	76.7	67.9	60.8	76.4
23	59.2	63.3	75.7	84.4	88.2	87.7	82.3	80.8	80.4	75.8	66.5	59.3	75.3
Mean	61.8	66.8	79.2	88.0	91.4	90.3	84.1	83.0	83.1	79.3	69.6	62.3	78.3

TABLE VI D.—*Normal hourly temperatures at the height of 104 feet.*

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
0	60.5	63.6	76.8	85.0	88.0	87.0	81.8	80.9	79.7	76.9	69.2	61.8	75.9
1	59.4	62.6	75.2	83.3	86.4	86.0	81.3	80.6	78.9	75.7	67.5	60.3	74.8
2	58.4	61.6	73.5	81.8	84.9	85.1	80.9	80.3	78.2	74.7	65.8	58.8	73.7
3	57.4	60.7	71.9	80.3	83.4	84.2	80.5	80.0	77.6	73.8	64.1	57.4	72.6
4	56.4	59.9	70.4	78.9	82.1	83.3	80.0	79.7	77.1	73.3	62.4	56.0	71.6
5	55.5	59.0	69.3	77.6	81.4	82.8	79.7	79.4	76.6	72.7	60.7	54.6	70.8

TABLE VI D.—Normal hourly temperatures at the height of 104 feet—continued.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
6	54.5	58.3	68.2	76.3	81.0	82.6	79.8	79.6	76.1	72.3	59.8	53.2	70.1
7	53.8	58.2	68.2	77.5	82.6	83.6	80.8	79.8	77.3	72.8	60.4	52.8	70.6
8	54.4	59.6	72.2	81.1	86.3	85.2	81.9	81.1	79.8	75.1	62.3	55.1	72.8
9	59.0	63.3	76.2	85.9	90.6	87.0	83.3	82.6	82.3	78.6	67.6	60.2	76.4
10	63.4	67.5	80.5	89.7	93.5	89.3	84.7	84.2	84.6	82.4	72.3	65.0	79.8
11	66.3	71.3	83.8	92.6	96.1	91.2	85.9	85.4	86.2	84.6	75.2	68.5	82.3
12	68.3	73.5	86.7	95.1	97.7	93.2	86.8	86.2	87.7	86.1	77.7	70.8	84.2
13	69.7	75.7	89.0	97.4	99.1	94.8	87.5	86.8	89.1	87.4	79.8	72.4	85.7
14	70.9	77.4	90.4	98.7	100.1	95.9	87.7	86.8	90.0	88.4	81.1	73.8	86.8
15	71.4	77.8	90.9	99.6	100.5	96.9	87.3	85.7	90.0	88.3	80.7	74.0	86.9
16	71.3	77.6	91.0	100.1	100.0	97.3	86.8	85.1	89.9	87.8	79.8	73.5	86.7
17	70.3	76.7	90.3	99.1	99.3	95.6	85.6	84.4	88.8	86.6	78.6	72.0	85.6
18	69.0	74.9	87.6	97.1	97.4	93.5	84.5	83.8	87.1	85.5	77.4	70.8	84.0
19	67.7	73.1	85.7	94.6	95.5	92.1	84.0	83.2	85.7	83.9	76.3	69.3	82.6
20	65.9	71.0	83.8	92.7	93.5	91.0	83.5	82.6	84.4	82.5	75.0	67.8	81.1
21	64.3	69.1	81.9	91.2	92.4	90.1	83.0	82.1	83.0	81.0	73.8	66.4	79.9
22	62.8	66.7	80.1	88.7	91.1	89.2	82.6	81.7	81.5	79.2	72.6	64.9	78.4
23	61.7	64.9	78.5	86.8	89.6	88.1	82.2	81.3	80.4	77.9	70.9	63.3	77.1
Mean	63.0	67.7	80.1	88.8	91.2	89.4	83.4	82.6	83.0	80.3	71.3	64.3	78.7

TABLE VI E.—Normal hourly temperatures at the height of 166 feet.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	August.	Sept.	Oct.	Nov.	Dec.	Year.
0	61.7	63.9	77.0	85.6	88.1	86.8	81.9	80.7	80.3	77.8	71.3	63.6	76.6
1	60.7	62.7	75.4	83.8	86.4	85.7	81.4	80.4	79.5	77.0	69.3	62.1	75.4
2	59.7	61.7	73.8	82.5	85.7	84.6	80.9	80.1	78.8	76.2	67.4	60.6	74.3
3	58.7	60.8	72.5	81.1	83.0	83.6	80.5	79.8	78.1	75.3	65.6	59.1	72.2
4	57.8	59.9	71.4	79.6	81.6	82.9	80.1	79.7	77.5	74.5	63.9	57.7	73.2
5	56.9	59.3	70.4	78.6	81.0	82.4	79.7	79.6	76.9	73.7	62.4	56.4	71.4
6	56.1	59.1	69.4	77.7	81.1	82.0	79.4	79.7	76.4	73.0	61.0	55.3	70.8
7	55.7	59.2	69.1	78.7	82.3	82.8	80.2	80.1	77.3	73.3	61.2	55.3	71.3
8	55.6	60.8	71.7	81.5	86.1	84.3	81.4	81.4	79.8	74.7	62.3	56.3	73.0
9	58.4	63.5	75.7	85.3	90.1	86.3	82.6	82.6	81.9	78.2	67.1	59.6	75.9
10	62.8	66.9	79.7	88.8	93.3	88.4	84.2	83.6	83.8	81.3	72.1	65.0	79.2
11	66.1	69.9	82.4	91.7	93.3	90.7	85.5	84.6	85.6	83.7	74.3	68.9	81.6

TABLE VI E.—*Normal hourly temperatures at the height of 166 feet—continued.*

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
12	68°3	72°4	84°8	95°0	97°4	92°4	86°6	85°6	87°3	85°6	77°4	71°0	83°6
13	70°1	74°5	86°4	96°5	98°6	93°7	86°9	86°5	88°8	87°0	79°3	72°6	85°1
14	71°2	76°2	87°9	98°0	99°5	95°0	87°2	86°7	90°0	88°3	80°9	73°9	86°2
15	71°5	77°0	88°5	98°6	100°0	95°7	86°8	86°4	90°0	88°2	80°6	74°1	86°5
16	71°0	76°8	88°9	99°2	99°2	95°9	85°8	85°7	89°7	87°7	80°0	73°9	86°2
17	69°9	76°3	88°3	98°4	98°2	94°3	84°6	85°1	88°7	86°5	78°2	72°6	85°1
18	68°6	74°2	86°2	96°6	96°6	92°6	84°0	84°4	86°4	84°8	77°1	71°3	83°6
19	67°4	72°6	84°2	94°8	95°3	91°6	83°6	83°8	86°1	83°7	76°3	70°1	82°5
20	66°3	70°8	83°0	93°2	94°1	90°4	83°2	83°8	84°7	82°4	75°4	68°8	81°3
21	65°1	68°8	81°5	91°8	92°9	89°6	82°9	82°5	83°4	81°1	74°6	67°6	80°2
22	63°8	66°5	80°2	89°4	91°4	88°9	82°6	81°9	82°0	79°8	73°5	66°3	78°9
23	62°8	65°1	78°7	87°3	89°8	87°9	82°3	81°3	81°2	78°7	72°3	65°0	77°7
Mean	63°6	67°5	79°5	88°9	91°1	88°7	83°1	82°7	83°1	80°5	71°8	65°3	78°8

This table shows, as did the original observations of the self-registering thermometers, that the daily range decreases on ascending in every month of the year. The probable values of the periodic maxima and minima and the times at which they occur, computed by Jelinek's method from the figures in the column of annual means, are the following:—

Height.	Minimum.		Maximum.	
	Time.	Temp.	Time.	Temp.
4 feet	5	36° 68°0	14	40° 88°9
46 "	5	45° 69°1	14	38° 87°9
104 "	6	5° 70°1	14	50° 86°9
166 "	6	3° 70°8	15	0° 86°2

These results evidently support the idea that the diurnal temperature wave is propagated upwards, as is generally understood, the atmosphere being diurnally heated and cooled chiefly by contact with the ground. The minimum is retarded 27 minutes and the maximum 20 minutes as the diurnal wave of temperature passes from 4 to 166 feet; at the same time the range is diminished from 20°9' to 15°4'. On the average of all the observations the range diminishes on ascending at a rate represented by the formula: $\log r = 1.324 - .091 h$, when h is given in hundreds of feet. At this rate the diurnal range would be reduced to 1° F at a height of 1,455 feet, but such a rapid rate cannot prevail to any great height. In fact, the range evidently does not diminish in geometrical progression as the height increases in arithmetical progression, for the ratio of diminution becomes less and less rapid as we go up instead of remaining constant. This result must follow from the known fact that the atmosphere is to some extent heated and cooled by direct radiation, as well as from below by processes analogous to conduction. The observations would be better satisfied by the equation: $\log r = 1.324 - .118 h + .023 h^2$,

according to which the very rapid rate of reduction of the daily range, seen in the above table, would disappear at about 250 or 260 feet from the ground.

The variations of temperature in the diurnal period at different heights can perhaps be best illustrated by the contour lines of a surface. Twelve such sets of isothermal contours, for the twelve months of the year, are shown on plates XXXIX, XL and XLI while plate XLII exhibits the curves for the whole year. It will be observed that both the highest and lowest isotherms on most of the diagrams are curved with the convexity upwards, this indicating that these extreme temperatures do not extend to any great height.

The rapid fall of temperature during the afternoons, indicated by the closeness of the isotherms at the bottom of the diagram between 14 and 18 hours, does not extend to any great height, the spaces between the lines widening out very perceptibly as the height increases during the afternoons and also, though to a less extent, in the mornings.

In constructing these diagrams the temperatures given in Table VI were marked off for each hour, along lines representing heights of 4, 46, 104 and 166 feet, and from the mean temperatures of Table V, and the computed departures from the mean at 6, 14 and 22 hours, computed values of the temperatures at these hours were laid down for every 20 feet of elevation up to 200 feet. These computed temperatures are given in Table VII.

TABLE VII A.—*Computed temperatures at 6 hours.*

FEET.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
0	51'2	52'8	62'6	72'2	80'2	83'5	81'3	80'1	77'9	70'3	56'3	48'9	68'1
20	52'0	54'3	64'0	73'3	80'4	83'3	80'9	79'8	77'5	70'8	57'2	50'1	68'6
40	52'7	55'6	65'3	74'2	80'6	83'1	80'6	79'5	77'1	71'3	57'8	51'2	69'0
60	53'4	56'6	66'4	75'0	80'8	82'9	80'3	79'4	76'7	71'7	58'5	52'7	69'4
80	54'0	57'5	67'3	75'7	80'9	82'7	80'1	79'4	76'4	72'1	59'2	53'0	69'8
100	54'5	58'2	68'1	76'2	81'0	82'6	79'9	79'4	76'2	72'4	59'7	53'7	70'1
120	54'9	58'7	68'7	76'7	81'0	82'4	79'7	79'5	76'0	72'6	60'2	54'3	70'3
140	55'4	59'0	69'1	77'1	81'0	82'3	79'6	79'6	76'0	72'8	60'6	54'8	70'6
160	55'9	59'1	69'4	77'5	81'1	82'1	79'5	79'7	76'3	73'0	60'9	55'1	70'8
180	56'3	59'1	69'5	77'8	81'1	81'9	79'4	79'9	76'7	73'1	61'2	55'3	71'0
200	56'7	59'0	69'4	77'9	81'1	81'8	79'3	80'2	77'2	73'2	61'4	55'6	71'1

TABLE VII B.—*Computed temperatures at 14 hours.*

FEET.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
0	71'3	78'5	92'8	101'8	103'5	100'3	90'6	88'7	92'0	88'3	81'6	74'3	88'6
20	71'3	78'4	92'5	101'1	102'6	99'1	89'9	88'0	91'7	88'4	81'6	74'2	88'2
40	71'2	78'2	92'1	100'3	101'9	98'1	89'3	87'4	91'3	88'5	81'5	74'1	87'8
60	71'2	78'0	91'7	99'7	101'3	97'3	88'7	87'1	90'9	88'5	81'5	74'1	87'5
80	71'1	77'8	91'2	99'3	100'7	96'6	88'2	86'9	90'5	88'5	81'4	74'0	87'2

TABLE VII B.—*Computed temperature at 14 hours—continued.*

FERT.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
100	70.9	77.5	90.6	98.8	100.2	96.0	87.8	86.8	90.1	88.4	81.2	73.9	86.9
120	71.0	77.2	89.9	98.5	99.8	95.6	87.5	86.8	89.9	88.4	81.0	73.8	86.6
140	71.1	76.8	89.2	98.2	99.7	95.3	87.3	86.8	89.8	88.4	80.8	73.8	86.4
160	71.2	76.4	88.3	98.0	99.6	95.1	87.2	86.7	89.9	88.3	80.9	73.9	86.3
180	71.2	75.9	87.3	97.8	99.5	94.9	87.1	86.7	90.1	88.3	81.0	74.0	86.2
200	71.3	75.3	86.0	97.7	99.5	94.8	87.0	86.7	90.4	88.2	81.1	74.1	86.0

TABLE VII C.—*Computed temperatures at 22 hours.*

FERT.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
0	56.9	60.8	72.6	82.1	88.1	88.7	83.1	81.8	80.3	73.6	62.0	55.3	73.8
20	58.4	62.5	74.8	84.0	88.9	88.9	82.9	81.6	80.6	75.1	64.7	58.0	75.0
40	59.7	63.9	76.5	85.5	89.6	89.0	82.8	81.3	80.9	76.4	67.2	60.3	76.1
60	60.9	65.0	77.9	86.8	90.2	89.1	82.8	81.3	81.2	77.5	69.2	62.2	77.0
80	61.9	65.9	79.1	87.8	90.7	89.2	82.7	81.4	81.4	78.4	70.9	63.7	77.7
100	62.7	66.6	79.9	88.6	91.1	89.2	82.6	81.6	81.5	79.1	72.3	64.9	78.3
120	63.2	67.0	80.4	89.1	91.4	89.2	82.6	81.7	81.7	79.6	73.4	65.7	78.7
140	63.5	67.0	80.5	89.4	91.5	89.1	82.6	81.8	81.8	79.9	73.8	66.2	78.9
160	63.7	66.7	80.4	89.5	91.4	89.0	82.6	81.9	81.9	79.9	73.7	66.4	79.0
180	63.8	66.2	79.8	89.4	91.2	88.9	82.7	82.0	82.0	79.6	72.9	66.2	78.7
200	63.8	65.4	79.0	89.1	90.9	88.7	82.8	82.1	82.1	79.2	71.7	65.7	78.3

In the diagrams for the several months the isotherms are drawn as a rule for intervals of 5 degrees, but in some cases additional isotherms, shown by dotted lines, have been inserted near the maximum and minimum regions of the diagram. The values of these are indicated by figures within brackets. In the large diagram for the whole year (Plate XLII) the lines are drawn at uniform intervals of 2 degrees.

ABSOLUTE HUMIDITY.

The absolute humidity of the air is usually measured by the tension or pressure of water vapour in it. This has been computed for each elevation from the individual observations of the dry and wet bulb thermometers by means of Table IV of the official collection of tables for the reduction of meteorological observations in India. This table is founded on August's psychrometric formula with Regnault's constants,¹ and in it the barometric pressure is assumed to be 29.7 inches. It probably gives results which are sensibly too high when the air is quite still, as it usually is during the nights of the dry season, especially during the colder months of the year, whilst the constant of the negative term of the formula is rather too great, and the results are consequently too low, when the instruments are exposed to a strong current of air, as they are in the afternoons of the hot weather.

¹ $f = f' - \frac{280(f-f')}{1130-f'} h$, when the temperatures f and f' are on Fahrenheit's scale.

The mean results for each of the regular hours of observation, together with the diurnal mean for each month of the whole period, are given in Tables VIII, A, B, C, D, and E. The diurnal means have been obtained from the crude means of the three or four observations here given by the application of small corrections derived from the hourly series in Table X.

TABLE VIII A.—*Vapour tension under shed.*

Months.	1886-87.					1887-88.				
	6 hours.	10 hours.	16 hours.	22 hours.	Mean.	6 hours.	10 hours.	16 hours.	22 hours.	Mean.
May	'642"	'612"	'496"	'613"	'592"	'565"	'538"	'431"	'541"	'520"
June	'760	'731	'666	'742	'748	'852	'809	'676	'790	'754
July	'964	'972	'956	'971	'965	'928	'955	'945	'947	'941
August	'926	'936	'937	'946	'939	'935	'965	'961	'953	'957
September	'891	'914	'895	'929	'914	'853	'880	'807	'851	'854
October	'783	'796	'705	'787	'771	'600	'625	'549	'636	'605
November	'450	'470	'403	'478	'453	'405	'423	'352	'438	'429
December	'362	'393	'382	'409	'391	'319	'364	'293	'365	'339
January	'348	'385	'347	'387	'370	'286	'311	'283	'327	'304
February	'267	'256	'197	'297	'260	'339	'347	'302	'360	'344
March	'352	'343	'244	'339	'324	'351	'328	'256	'347	'324
April	'417	'392	'291	'418	'378	'383	'349	'244	'361	'334
Year	'597	'600	'543	'610	'590	'568	'574	'508	'576	'559

TABLE VIII B.—*Vapour tension at the height of 6 feet.*

Months.	1886-87.				1887-88.			
	6 hours ¹ .	14 hours ¹ .	22 hours ¹ .	Mean.	6 hours ¹ .	14 hours ¹ .	22 hours ¹ .	Mean.
May	'622"	'495"	'599"	'567"	'578"	'450"	'548"	'520"
June	'792	'745	'778	'774	'861	'709	'793	'790
July	'982	'984	'990	'984	'933	'963	'957	'950
August	'938	'946	'963	'951	'933	'965	'959	'954
September	'898	'877	'941	'922	'853	'823	'860	'862
October	'788	'734	'803	'790	'610	'567	'641	'621
November	'460	'400	'498	'469	'411	'383	'449	'430
December	'369	'372	'415	'401	'327	'307	'370	'351
January	'348	'355	'393	'370	'297	'295	'337	'315
February	'286	'230	'309	'279	'347	'310	'372	'347
March	'363	'277	'358	'339	'361	'277	'369	'342
April	'416	'295	'417	'379	'411	'287	'389	'365
Year	'605	'559	'622	'602	'577	'528	'587	'571

¹ At 10 minutes before the hour named.

TABLE VIII C.—*Vapour tension at the height of 46 feet.*

MONTHS.	1886-87.				1887-88.			
	6 hours ¹ .	14 hours ¹ .	22 hours ¹ .	Mean.	6 hours ¹ .	14 hours ¹ .	22 hours ¹ .	Mean.
May	'630 ⁹	'489 ⁹	'596 ⁹	'567 ⁹	'520 ⁹	'379 ⁹	'455 ⁹	'446 ⁹
June	'756	'691	'730	'726	'825	'644	'744	'738
July	'960	'928	'963	'951	'909	'882	'930	'908
August	'924	'891	'940	'921	'916	'905	'940	'923
September	'886	'818	'901	'883	'837	'756	'821	'820
October	'793	'694	'756	'725	'597	'498	'565	'564
November	'465	'361	'444	'433	'405	'315	'392	'381
December	'375	'341	'396	'379	'333	'263	'328	'316
January	'352	'326	'375	'354	'286	'253	'302	'283
February	'256	'177	'249	'233	'330	'276	'323	'316
March	'328	'208	'276	'279	'315	'212	'282	'278
April	'370	'237	'338	'316	'352	'206	'282	'281
Year	'591	'513	'580	'564	'552	'466	'530	'521

¹At 10 minutes before the hour named.TABLE VIII D.—*Vapour tension at the height of 104 feet.*

MONTHS.	6 hours.	14 hours.	22 hours.	Mean.
May 1887	'530 ⁹	'425 ⁹	'478 ⁹	'461 ⁹
June "	'831	'648	'743	'733
July "	'908	'878	'917	'908
August "	'922	'902	'928	'924
September "	'839	'756	'801	'807
October "	'573	'488	'535	'552
November "	'393	'332	'353	'364
December "	'309	'290	'308	'313
January 1888	'277	'274	'282	'286
February "	'320	'299	'317	'320
March "	'309	'269	'289	'294
April "	'357	'260	'285	'311
Year	'547	'485	'520	'523

TABLE VIII E.—*Vapour tension at the height of 166 feet.*

MONTHS.		6 hours.	14 hours.	22 hours.	Mean.
May 1887		'497"	'381"	'431"	'425"
June "		'812	'633	'725	'705
July "		'905	'875	'908	'905
August "		'916	'899	'922	'917
September "		'838	'745	'785	'797
October "		'540	'471	'506	'526
November "		'372	'326	'327	'349
December "		'280	'281	'279	'286
January 1888		'258	'266	'263	'270
February "		'303	'284	'292	'300
March "		'275	'239	'257	'264
April "		'325	'232	'263	'286
Year		'527	'469	'496	'503

From the above tables it appears that the vapour tensions deduced from the observations made under the pent-house at 6 feet are, on the whole, somewhat greater than those in the open shed. On the average of the year the difference amounts to only '012", or 2 per cent. of the annual mean, and its variations from month to month are quite irregular. These small differences are doubtless to be attributed to the better ventilation of the open shed upon the whole, though during the prevalence of certain winds, especially those blowing from nearly due west or east, there is little difference in this respect. Since the period of observation is rather short the mean of the two sets may be taken for comparison with the various tower observations, and the whole of the observations may be reduced to normal values by adding to the actual monthly means the differences between the values thus found 4 feet, and the normal means of twelve years at the process being analogous to that above adopted for finding the normal mean temperatures. The results are as follows:—

TABLE IX.—*Normal values of vapour tension.*

HEIGHT.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
4 feet.	'335"	'291"	'370"	'395"	'539"	'770"	'938"	'932"	'872"	'603"	'377"	'327"	'562"
46 "	'309	'261	'316	'330	'496	'735	'908	'903	'835	'551	'339	'304	'524
104 "	'301	'266	'331	'356	'480	'731	'901	'900	'821	'542	'312	'295	'520
166 "	'285	'246	'301	'331	'444	'703	'898	'893	'811	'516	'297	'268	'500

This table shows that whilst in every month of the year, particularly in the drier ones, there is apparently a very rapid decrease of vapour pressure as the height increases, the Muir College site, where the two highest sets of observations were made, is probably by nature rather more humid than that of the observatory, especially in the months

of March and April. This is probably owing to its being near the Alfred Park and a number of private gardens in which the grass and shrubs are irrigated during the rainless months.

If we adopt Hann's formula for the vertical distribution of vapour, *viz.* $\log f = \log F - a h$, and compute the value of the constant a for each month by comparing the value of f at 4 feet with that at each of the other three heights given in Table VIII, and, taking the mean of the three results, we get the following mean values, h being understood to be expressed in thousands of feet:—

Month.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.
Value of a .	'543	'656	'873	'928	'628	'317	'206	'193	'301	'604	'772	'577

The rate of decrement of $\log f$ deduced from the observations at 46 feet is in every month considerably greater than those obtained from the other two series, doubtless owing to the very rapid increase of the wind velocity in the first few feet above the ground; this increase of velocity accentuating the difference between the readings of the dry and wet bulb thermometers, and making the air at the top of the tower appear drier than it really is in comparison with that below. For the same reason the hourly observations in Table X indicate (as do the midday observations of Alipore published in Vol. II) a more rapid decrease of humidity in the hot weather afternoons than at other times of the day, the winds being very strong at the hottest time of the day and dying away during the night. Nevertheless, the variations of wind velocity are not, as I supposed they were when discussing the Alipore observations (Vol. II, pages 464 and 465), sufficient to account for the whole of the extremely rapid mean rates of decrease of vapour tension above given; for these are evidently subject to a double oscillation in the annual period, whilst there is only one such variation in the wind velocity, and the most rapid decrease of all occurs about 7 to 10 P.M. in the cold weather, when there is no wind at all. The constant of the logarithmic formula for the pressure of vapour appears in fact to be directly related to the dryness of the air and inversely to the velocity of the wind. If we measure the dryness of the air by $(100-H)$, where H is the relative humidity, expressed as a percentage, and divide the resulting values by the velocity of the wind in miles per diem, we get a series of quotients nearly identical with the values of a in the above formula, thus:—

	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.
H^1	69	57	44	33	40	55	81	82	81	69	64	69
V^1	47	67	74	78	95	98	100	87	69	39	30	36
$\frac{100-H}{v}$	'468	'642	'757	'859	'632	'459	'190	'207	'275	'795	1'200	'867

These fractions, together with the values of a , are plotted in Fig. IV, Plate XLIII. It will be seen, on inspection of the curves, that their periodicity is the same, and the actual agreement in value is fairly close for every month of the year except October, November, and December; when the velocity of the wind is so very low that the frictional retardation of the anemometer accounts for a considerable fraction of it, and the recorded velocity is thus reduced, so as to give exaggerated values of the fraction $\frac{100-H}{v}$. The coincidence in numerical value is merely a fortuitous result of the scale employed in each case, but the parallelism of the two curves indicates that a really does vary directly with $100-H$ and inversely with v . The explanation of this probably is that in dry weather the moisture present in the first two or three hundred feet of air is derived chiefly from the ground

¹ Means of many years.

immediately under the place of observation, and that the vapour rising from the ground diffuses upwards but slowly when the air is still, while when a wind is blowing there is a more rapid upward movement by convection and admixture of the various strata.

The diurnal variation of the vapour tension at each elevation may be seen from Table X, which gives the hourly values. These agree fairly well with those already published for a longer period of observation at the old observatory.¹ In most months they indicate a double periodicity, in which the forenoon maximum and afternoon minimum coincide approximately with those of barometric pressure, whilst there is much less regularity about the critical phases during the night, and in some cases there is a tendency to the formation of two nocturnal maxima.

TABLE X A.—*Vapour tension under shed (corrected to 2 years).*

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
0	'340	'325	'354	'373	'568	'786	'949	'945	'888	'700	'454	'379	'604
1	'332	'323	'356	'365	'573	'788	'948	'941	'892	'700	'452	'373	'587
2	'330	'316	'357	'372	'588	'787	'946	'941	'887	'696	'446	'366	'586
3	'327	'311	'354	'379	'598	'786	'944	'940	'880	'693	'442	'356	'584
4	'322	'307	'347	'388	'601	'790	'940	'936	'872	'688	'436	'349	'581
5	'319	'303	'345	'392	'606	'795	'940	'931	'868	'683	'428	'341	'579
6	'317	'303	'352	'400	'603	'806	'946	'930	'872	'692	'428	'340	'583
7	'323	'308	'358	'409	'607	'807	'952	'930	'885	'704	'443	'359	'591
8	'330	'313	'362	'407	'605	'803	'957	'936	'898	'719	'455	'373	'596
9	'339	'308	'351	'393	'593	'785	'961	'943	'900	'718	'457	'385	'594
10	'348	'302	'336	'370	'575	'770	'964	'950	'897	'710	'446	'374	'587
11	'344	'288	'312	'345	'551	'742	'968	'959	'891	'686	'424	'365	'573
12	'333	'277	'292	'315	'530	'718	'964	'964	'878	'658	'394	'345	'556
13	'320	'267	'278	'299	'514	'693	'959	'968	'865	'634	'369	'325	'540
14	'310	'259	'267	'283	'495	'677	'952	'959	'840	'622	'349	'312	'528
15	'309	'250	'258	'276	'482	'672	'952	'956	'842	'615	'341	'306	'521
16	'315	'250	'250	'268	'464	'671	'950	'949	'851	'627	'378	'338	'526
17	'345	'269	'263	'285	'469	'678	'946	'951	'879	'670	'428	'382	'549
18	'368	'304	'292	'323	'498	'698	'950	'952	'908	'710	'468	'415	'574
19	'377	'330	'325	'361	'537	'728	'961	'957	'919	'728	'471	'414	'593
20	'367	'340	'339	'388	'565	'751	'971	'957	'914	'720	'466	'399	'598
21	'359	'333	'340	'393	'577	'760	'969	'952	'899	'715	'463	'393	'597
22	'357	'328	'343	'390	'577	'766	'959	'950	'890	'712	'458	'387	'593
23	'347	'326	'349	'380	'569	'777	'952	'948	'883	'710	'455	'383	'590
Mean	'337	'302	'324	'356	'556	'751	'954	'948	'884	'688	'431	'365	'575

¹ Vol. I, pages 333 and 334.

TABLE X B.—*Vapour tension at the height of 6 feet (corrected to 2 years).*

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
0	"	"	"	"	"	"	"	"	"	"	"	"	"
1	'347	'335	'365	'390	'561	'809	'966	'955	'896	'706	'463	'382	'598
2	'340	'331	'364	'386	'562	'813	'964	'952	'901	'703	'465	'378	'596
3	'336	'327	'362	'391	'578	'805	'960	'951	'895	'699	'461	'372	'595
4	'332	'321	'363	'395	'589	'804	'956	'948	'888	'696	'455	'365	'593
5	'327	'320	'360	'394	'593	'806	'953	'941	'878	'694	'449	'359	'590
6	'324	'316	'358	'399	'598	'812	'953	'935	'870	'691	'439	'352	'587
7	'322	'316	'362	'414	'600	'826	'958	'936	'876	'699	'436	'348	'591
8	'325	'321	'372	'428	'601	'834	'964	'937	'891	'716	'451	'358	'600
9	'331	'324	'381	'431	'596	'838	'971	'947	'912	'742	'467	'377	'609
10	'339	'320	'377	'418	'582	'823	'977	'954	'920	'748	'479	'397	'612
11	'345	'312	'357	'395	'560	'813	'982	'960	'916	'739	'474	'396	'605
12	'345	'296	'331	'368	'533	'785	'982	'963	'901	'714	'454	'388	'589
13	'338	'287	'305	'338	'507	'763	'980	'968	'881	'691	'432	'372	'572
14	'330	'273	'289	'311	'489	'740	'975	'965	'864	'665	'403	'352	'555
15	'325	'270	'277	'291	'472	'727	'974	'956	'850	'650	'392	'340	'544
16	'325	'266	'269	'283	'459	'713	'971	'949	'851	'643	'386	'332	'537
17	'332	'267	'268	'286	'451	'706	'964	'949	'860	'655	'409	'352	'542
18	'350	'284	'285	'299	'459	'709	'959	'950	'890	'692	'440	'381	'558
19	'370	'314	'314	'331	'485	'729	'959	'955	'915	'727	'471	'411	'582
20	'376	'339	'342	'368	'521	'753	'971	'961	'927	'744	'479	'415	'599
21	'371	'348	'358	'398	'548	'778	'980	'963	'922	'736	'479	'407	'608
22	'366	'343	'361	'404	'566	'784	'981	'962	'910	'731	'476	'399	'607
23	'365	'340	'364	'403	'574	'786	'974	'961	'900	'722	'474	'392	'605
24	'356	'337	'364	'395	'566	'802	'969	'960	'896	'715	'468	'386	'604
Mean	'342	'313	'340	'372	'544	'782	'968	'953	'892	'705	'450	'376	'586

TABLE X C.—*Vapour tension at the height of 46 feet (corrected to 2 years).*

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
0	"	"	"	"	"	"	"	"	"	"	"	"	"
1	'326	'305	'299	'314	'525	'768	'942	'938	'874	'671	'440	'366	'564
2	'322	'311	'313	'318	'532	'774	'942	'935	'889	'679	'443	'366	'569
3	'324	'307	'311	'326	'555	'771	'936	'932	'883	'678	'444	'367	'570
4	'326	'305	'319	'334	'568	'772	'932	'931	'878	'680	'445	'365	'571

TABLE X C.—*Vapour tension at the height of 46 feet (corrected to 2 years)*—continued.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
4	'323	'303	'318	'341	'573	'776	'932	'927	'868	'682	'443	'357	'570
5	'318	'298	'322	'350	'575	'782	'932	'922	'864	'688	'441	'355	'570
6	'319	'293	'322	'361	'575	'790	'934	'920	'862	'695	'435	'354	'572
7	'314	'294	'325	'368	'568	'796	'934	'915	'869	'702	'439	'360	'573
8	'313	'289	'321	'362	'559	'794	'934	'912	'875	'709	'435	'363	'572
9	'314	'277	'315	'339	'537	'776	'930	'911	'873	'698	'428	'366	'564
10	'319	'261	'298	'314	'512	'755	'926	'911	'859	'678	'413	'357	'550
11	'318	'242	'270	'287	'486	'725	'923	'914	'839	'648	'395	'345	'533
12	'309	'232	'245	'264	'467	'705	'915	'912	'816	'625	'374	'326	'516
13	'298	'225	'220	'239	'450	'683	'909	'907	'799	'603	'354	'310	'499
14	'290	'226	'210	'222	'434	'668	'905	'898	'787	'596	'338	'302	'489
15	'292	'225	'203	'217	'422	'653	'912	'901	'794	'593	'334	'298	'487
16	'302	'230	'207	'219	'420	'648	'914	'908	'808	'607	'351	'317	'494
17	'320	'248	'220	'234	'429	'654	'916	'916	'838	'638	'378	'335	'501
18	'334	'270	'246	'257	'452	'669	'918	'924	'857	'662	'394	'350	'528
19	'339	'282	'265	'280	'477	'688	'932	'931	'865	'674	'395	'349	'539
20	'340	'283	'273	'295	'495	'709	'947	'935	'864	'665	'395	'348	'546
21	'338	'283	'276	'303	'511	'725	'952	'938	'863	'662	'405	'354	'551
22	'338	'286	'279	'310	'526	'737	'946	'940	'861	'660	'418	'362	'555
23	'331	'296	'292	'312	'524	'755	'943	'942	'866	'665	'429	'364	'560
Mean	'319	'274	'278	'299	'507	'732	'929	'922	'852	'661	'407	'347	'544

TABLE X D.—*Vapour tension at the height of 104 feet (corrected to 1 year).*

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
0	'292	'343	'299	'295	'443	'736	'917	'944	'846	'600	'359	'313	'532
1	'302	'353	'308	'322	'429	'725	'926	'944	'869	'625	'356	'314	'540
2	'297	'349	'306	'353	'444	'739	'932	'941	'863	'614	'358	'315	'542
3	'292	'338	'304	'370	'465	'761	'925	'941	'856	'597	'363	'313	'544
4	'285	'328	'298	'364	'483	'786	'913	'935	'849	'579	'373	'309	'542
5	'280	'320	'300	'356	'506	'809	'909	'933	'844	'573	'388	'308	'543
6	'277	'320	'309	'357	'530	'831	'908	'922	'839	'573	'393	'309	'548

TABLE X D.—*Vapour tension at the height of 104 feet (corrected to 1 year)*—continued.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
7	.286	.334	.323	.383	.535	.850	.915	.920	.836	.592	.396	.319	.557
8	.300	.350	.335	.395	.518	.850	.918	.919	.831	.609	.401	.330	.563
9	.309	.354	.338	.390	.491	.826	.917	.923	.817	.624	.402	.343	.561
10	.316	.340	.331	.353	.465	.784	.915	.929	.808	.609	.400	.351	.550
11	.303	.321	.315	.320	.455	.735	.914	.927	.793	.583	.383	.344	.533
12	.297	.311	.298	.285	.447	.691	.905	.920	.779	.536	.368	.320	.513
13	.279	.304	.281	.273	.434	.669	.894	.913	.767	.511	.344	.298	.497
14	.274	.299	.269	.260	.425	.648	.878	.902	.756	.488	.332	.290	.485
15	.267	.288	.256	.254	.419	.625	.877	.907	.749	.488	.331	.288	.479
16	.264	.286	.248	.246	.418	.627	.880	.906	.741	.488	.341	.296	.478
17	.267	.285	.251	.252	.427	.639	.880	.916	.747	.484	.348	.299	.483
18	.268	.289	.261	.258	.429	.670	.897	.915	.774	.486	.351	.308	.492
19	.273	.296	.274	.265	.445	.677	.910	.921	.785	.486	.349	.306	.499
20	.281	.304	.281	.268	.449	.697	.925	.919	.795	.498	.350	.307	.506
21	.284	.312	.286	.275	.467	.719	.919	.923	.792	.515	.351	.305	.512
22	.282	.317	.289	.285	.478	.743	.917	.928	.801	.535	.353	.308	.520
23	.286	.327	.293	.286	.461	.748	.908	.940	.822	.572	.355	.309	.526
Mean	.286	.320	.294	.311	.461	.733	.908	.924	.807	.552	.364	.313	.523

TABLE X E.—*Vapour tension at the height of 166 feet (corrected to 1 year).*

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
9	.275	.322	.270	.283	.405	.718	.923	.943	.840	.552	.336	.287	.513
1	.279	.338	.270	.312	.399	.712	.934	.946	.866	.571	.338	.286	.521
2	.268	.336	.271	.341	.420	.725	.925	.940	.862	.574	.338	.286	.524
3	.261	.331	.269	.358	.443	.750	.918	.937	.852	.564	.345	.277	.525
4	.259	.320	.266	.344	.458	.772	.907	.931	.845	.553	.363	.272	.524
5	.258	.310	.266	.329	.479	.795	.905	.944	.841	.544	.369	.273	.524
6	.258	.303	.275	.325	.497	.812	.905	.916	.838	.540	.372	.280	.527
7	.262	.314	.290	.348	.513	.830	.914	.917	.834	.559	.370	.290	.537
8	.275	.322	.305	.359	.499	.826	.912	.915	.829	.578	.380	.306	.542
9	.283	.326	.307	.355	.481	.805	.908	.916	.809	.599	.386	.321	.541
10	.292	.315	.298	.323	.446	.764	.906	.913	.797	.586	.385	.334	.530
11	.288	.303	.282	.294	.428	.719	.915	.911	.783	.566	.371	.326	.516
12	.281	.293	.269	.260	.410	.675	.913	.911	.772	.528	.352	.305	.497

TABLE X E.—*Vapour tension at the height of 166 feet (corrected to 1 year)*—continued.

Hour.	Jan.	Feb.	March.	April.	May.	June.	July.	Aug.	Sept.	Oct.	Nov.	Dec.	Year.
13	'272	'285	'253	'246	'397	'649	'898	'909	'754	'499	'331	'289	'432
14	'266	'284	'239	'232	'381	'633	'875	'899	'745	'471	'326	'281	'469
15	'265	'286	'223	'222	'376	'613	'876	'887	'742	'464	'337	'278	'463
16	'264	'264	'217	'215	'373	'610	'875	'883	'742	'461	'342	'276	'460
17	'267	'258	'214	'223	'380	'616	'873	'899	'736	'458	'340	'271	'461
18	'267	'263	'223	'233	'381	'640	'889	'904	'745	'467	'334	'270	'468
19	'268	'272	'231	'239	'391	'657	'902	'915	'753	'479	'333	'266	'476
20	'268	'279	'239	'237	'400	'677	'919	'914	'766	'487	'334	'269	'482
21	'267	'287	'244	'247	'415	'705	'913	'918	'773	'496	'332	'273	'489
22	'263	'292	'257	'263	'431	'725	'908	'922	'785	'506	'327	'279	'496
23	'269	'307	'263	'275	'417	'731	'914	'935	'810	'529	'333	'280	'505
Mean	'270	'300	'264	'286	'425	'715	'905	'917	'797	'526	'349	'286	'503

The curves of hourly means are drawn on Plate XLIII, Figures I, II and III, the months being combined into three groups, November to February, March to May, and June to October, representing the cold, the hot and the rainy season, respectively. There is a general similarity in all four curves for each season, except that the very rapid rise of the vapour pressure occurring between 15 or 16 hours and 19 or 20 hours is confined to the lowest stratum, the evening rise at higher levels being much slower and attaining its maximum after midnight. The reason of this is probably that which has already been given by Mr. Blanford. The afternoon minimum is due to the admixture of dry air brought down from higher strata by convection currents; this convection diminishes after 4 P.M. and ceases about sunset, then the moisture rising from the ground by local evaporation rapidly accumulates in the lowest stratum, and only after a time diffuses away upwards.

RELATIVE HUMIDITY.

The mean value of the relative humidity of the air for each hour, month and place of observation might be approximately derived from the data already given for temperature and pressure of vapour. It is known, however, that when thus calculated the mean humidity, as a rule, does not agree with that deduced from the individual observations, because the mean value of a number of fractions is not necessarily identical with the quotient of the sum of the numerators by that of the denominators, nor is the average of the tensions of saturated vapour at a number of different temperatures identical with the tension at the mean temperature. The relative humidity has therefore been computed from every observation of the two thermometers, but it is needless to publish the hourly means, for the diurnal variation of vapour tension is so small in comparison with that of temperature that the degree of humidity is always least when the temperature is highest, and *vice versa*.

TEMPERATURE AND HUMIDITY

TABLE XI A.—*Monthly mean relative humidity under shed.*

MONTHS.	1886-87.					1887-88.				
	6 hours.	10 hours.	16 hours.	22 hours.	Mean.	6 hours.	10 hours.	16 hours.	22 hours.	Mean.
May	64	38	25	46	43	52	32	21	39	36
June	67	51	43	59	55	73	50	36	57	55
July	92	81	75	89	85	92	78	72	87	82
August	93	78	72	87	82	94	82	79	92	87
September	94	75	68	90	82	90	70	61	82	76
October	94	72	56	89	77	88	58	44	78	67
November	91	50	35	77	63	88	49	33	76	62
December	90	62	46	83	70	91	52	33	78	63
January	91	67	43	84	72	84	59	42	78	66
February	71	36	19	56	46	77	47	32	65	55
March	62	31	17	42	38	57	27	16	40	35
April	53	26	15	39	33	43	21	12	29	26
Year	80	56	43	70	62	77	52	40	67	59

TABLE XI B.—*Monthly mean relative humidity at the height of 6 feet.*

MONTHS.	1886-87.				1887-88.			
	6 hours.	14 hours.	22 hours.	Mean.	6 hours.	14 hours.	22 hours.	Mean.
May	61	27	45	44	52	23	39	38
June	70	46	61	59	72	37	56	55
July	94	76	90	87	91	72	87	83
August	93	72	88	84	94	77	91	87
September	93	66	90	83	89	61	81	77
October	93	61	87	80	85	47	76	69
November	87	39	76	67	84	39	75	66
December	88	49	82	73	88	38	76	67
January	90	52	83	75	85	46	77	69
February	73	26	56	52	77	36	65	59
March	60	21	43	41	56	19	41	39
April	51	16	37	35	44	14	30	29
Year	79	46	70	65	76	42	65	61

TABLE XI C.—*Monthly mean relative humidity at the height of 46 feet.*

MONTHS.	1886-87.				1887-88.			
	6 hours.	14 hours.	22 hours.	Mean.	6 hours.	14 hours.	22 hours.	Mean.
May	60	28	42	43	47	21	32	33
June	67	44	57	56	71	37	54	54
July	92	74	87	84	91	69	86	82
August	92	70	85	82	93	76	91	87
September	92	63	84	80	88	57	76	74
October	90	57	77	75	80	41	61	61
November	79	34	58	57	75	32	56	54
December	82	44	68	65	81	31	57	56
January	86	47	72	68	77	42	62	60
February	57	19	38	38	70	33	52	52
March	49	16	29	31	45	15	28	29
April	42	13	27	27	37	11	20	23
Year	74	42	60	59	71	39	56	55

TABLE XI D.—*Monthly mean relative humidity at the height of 104 feet.*

MONTHS.	6 hours.	14 hours.	22 hours.	Mean.
May 1887	48	23	33	35
June "	72	38	54	55
July "	92	70	86	83
August "	95	77	91	88
September "	88	60	74	74
October "	73	41	55	56
November "	67	35	46	49
December "	65	36	47	49
January 1888	69	44	54	56
February "	62	35	47	48
March "	41	20	27	29
April "	35	13	19	22
Year	67	41	53	54

TABLE XI E.—*Monthly mean relative humidity at the height of 166 feet.*

MONTHS.					6 hours.	14 hours.	22 hours.	Mean.
May	1887	.	.	.	45	22	30	32
June	"	.	.	.	71	38	53	54
July	"	.	.	.	93	71	85	83
August	"	.	.	.	94	78	90	87
September	"	.	.	.	87	59	72	73
October	"	.	.	.	67	40	51	53
November	"	.	.	.	60	34	41	45
December	"	.	.	.	55	34	41	43
January	1888	.	.	.	63	43	50	52
February	"	.	.	.	57	34	42	44
March	"	.	.	.	35	18	23	25
April	"	.	.	.	31	12	17	20
Year	"	.	.	.	63	40	50	51

Table XI gives for all five series of observations the mean humidity of each month at each of the regular hours of observation, together with the diurnal mean, which in this case does not differ from the simple average of three or four observations.

Reduced to normal values (12 years) by a process analogous to those already adopted for temperature and vapour tension, the monthly means are as shown in Table XII.

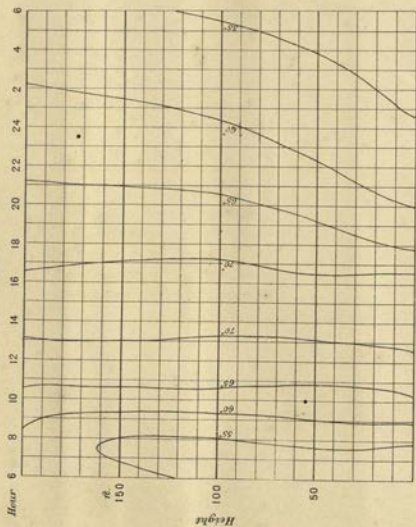
TABLE XII.—*Normal values of relative humidity.*

Hght.	Jan.	Feb.	March.	April.	May.	June.	July.	Augt.	Sept.	Oct.	Nov.	Dec.	Year.
4 feet	69	57	44	33	40	55	81	82	81	69	64	69	62
46 "	64	52	37	29	38	55	81	82	79	65	57	63	58
104 "	59	50	38	29	39	55	82	83	79	58	51	55	57
166 "	55	46	34	27	36	54	82	82	78	55	47	49	54

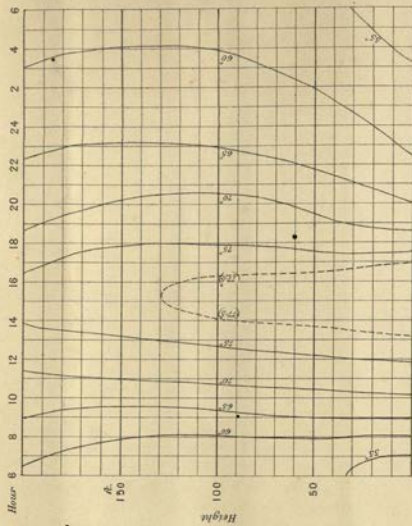
This table, like Table VIII, shows that the College grounds, where the upper two series of observations were made, are slightly damper than those of the observatory in March, April and May. In the other dry months there is a rapid decrease of humidity upwards, especially in the evenings, whilst in June, July and August the air is equally moist at all four elevations. Except just before and during the continuance of the rainy season, it would therefore appear that the moisture of the lower atmospheric strata over Allahabad is in great part derived, as above surmised, from local evaporation.

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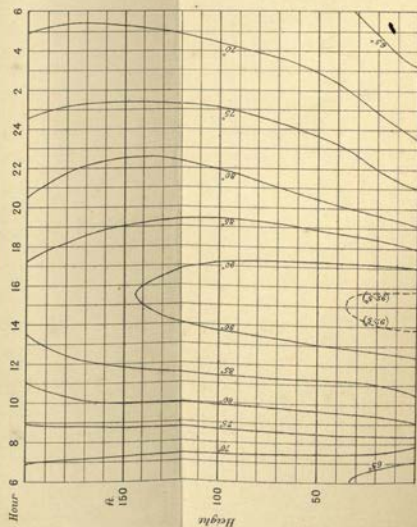
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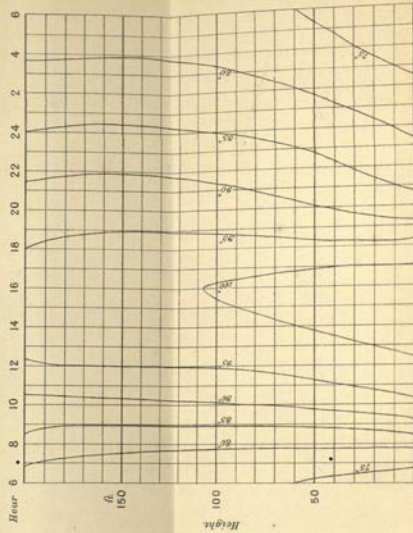
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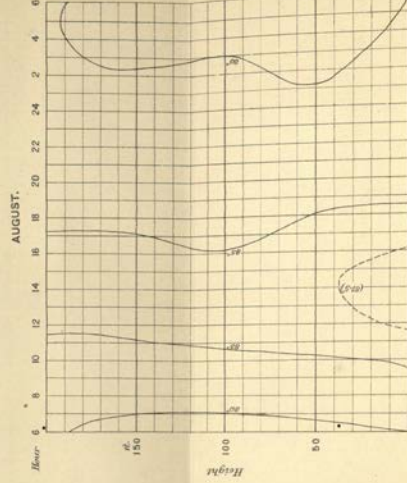
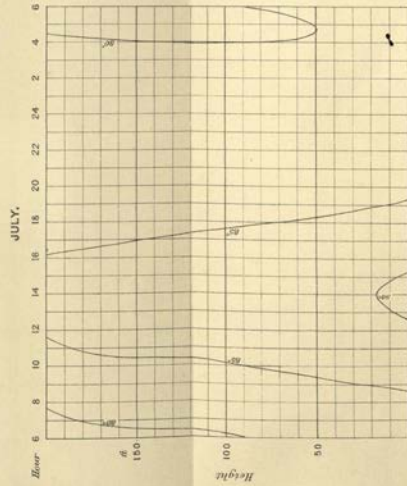
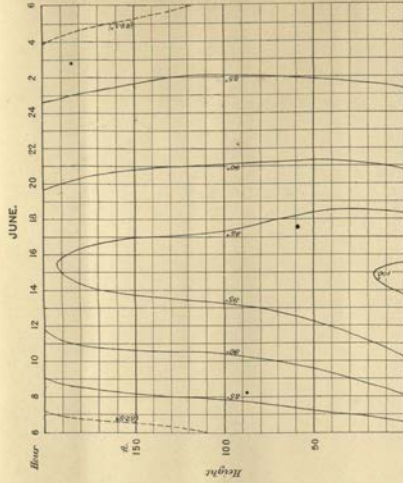
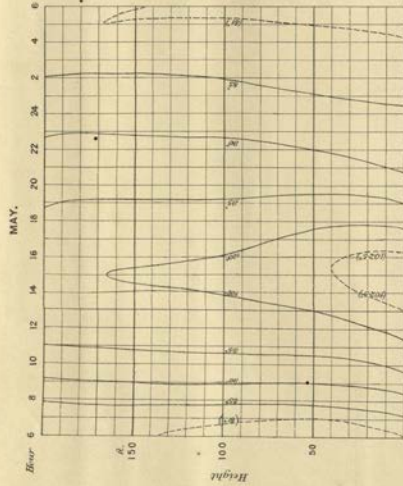
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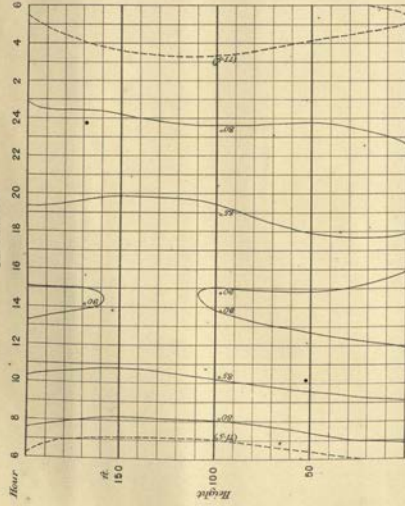
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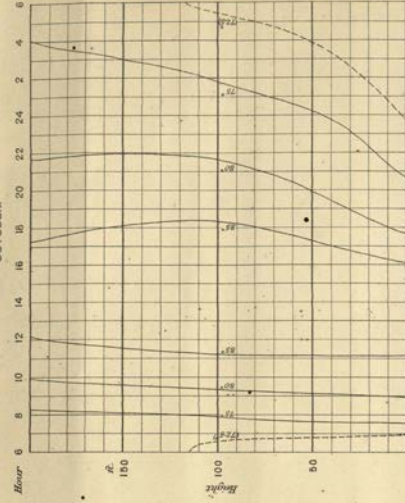
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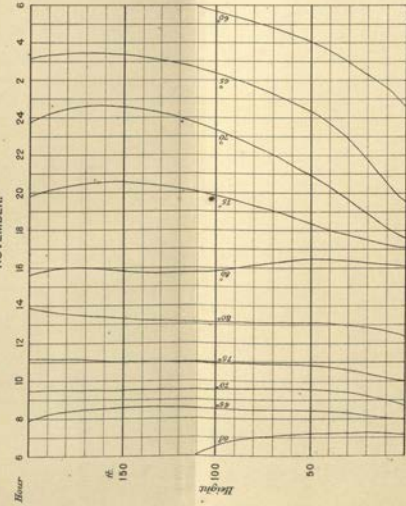
SEPTEMBER.



OCTOBER.



NOVEMBER.



CONTOUR LINES OF THERMAL SURFACES—IV.

Indian Met. Memoirs, Vol. IV, No. 9.

YEAR.

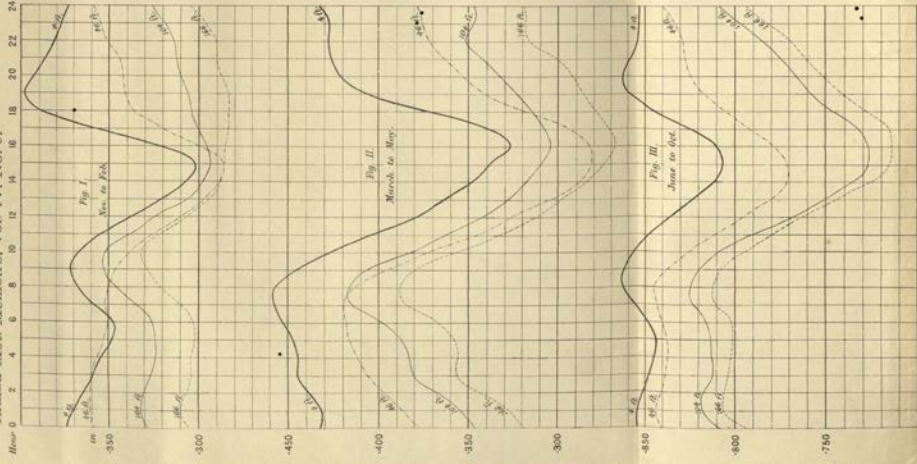
Plate XLII.



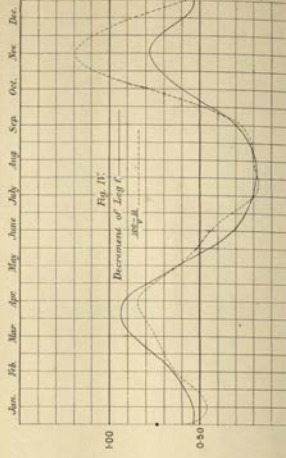
VAPOUR TENSION

Diurnal Variation.

Indian Met. Memoirs, Vol. IV, No. 9.



VAPOUR TENSION Rate of Decrement with Height.



CORRIGENDA

IN VOL. III OF THE INDIAN METEOROLOGICAL MEMOIRS.

- Page, 16, lines 8 and 17, for *millimeters* read *millimètres*.
" 26, line 26, for *lat. 9° 53' N* read *lat. 9° 58' N*.
" 93, " 21, for *Plato V* read *Plate IV*.
" 136, " 44, for *Metteilungen* read *Mittheilungen*.
" 161, in heading of section, for *xxx* read *NINE*, and for *1884* read *1883*.
" 196, line 13, in the () insert p. 250.

*X.—The Arabian Sea Cyclone of the 4th to the 13th June 1887, with a demonstration of the practicability of foretelling storms by the method of abnormals two or three days sooner than by the ordinary method of actuals, by FREDERICK CHAMBERS, lately Meteorological Reporter for Western India.*¹

RECEIVED ON THE 10TH JUNE 1889.

INTRODUCTION.

This paper gives an account of the cyclone which occurred in the Arabian Sea between the 4th and the 13th of June 1887. In the first chapter a few remarks are made on the meteorology of the Arabian Sea, pointing out how the monthly weather charts of the Arabian Sea, recently compiled by Mr. W. L. Dallas, and published by the Meteorological Department of the Government of India, confirm the inferences previously² drawn from the Admiralty charts, and from long continued observations recorded at stations on the shores

¹ The present cyclone report and that of the cyclone of the 25th May to the 2nd June 1881 in the Arabian Sea, given in Volume IV, Part V of the Indian Meteorological Memoirs, were compiled by Mr. F. Chambers, late Meteorological Reporter for Western India, at the express request of the Government of India conveyed in the following words, in a letter from Mr. Blanford, formerly Meteorological Reporter to the Government of India, dated 29th April 1887:—

"There are two subjects more especially on which information is much required and on which at different times you or your representative in the office have been requested to report. One of these is the meteorological conditions that have caused destructive floods in the rivers of the northern districts of Bombay on several occasions during the last few years. The other is a knowledge of the tracks followed by cyclones in the Arabian Sea, for which I understand you have collected much material. In the case of such storms as have crossed from the Bay of Bengal, it will not be necessary for you to deal with the earlier stages of their existence, as this either has been done or is now being done by Mr. Eliot."

The report of the cyclone of 25th May to 2nd June 1881 in the Arabian Sea was printed at Mr. Chambers' wish as speedily as possible, the publication of other memoirs which had been received being delayed in order to comply with Mr. Chambers' request. The present report has been printed in the ordinary course of publication of these memoirs.

The report is printed as received from Mr. Chambers, with the exception of the correction of obvious clerical mistakes, and the present Editor of the Indian Meteorological Memoirs does not hold himself responsible for all the views put forward by Mr. Chambers in this or the previous cyclone report.

It also appears to be desirable to place on record in this place that the use of abnormals for forecasting weather in India at the present time is the natural outcome of the meteorological system established in India in 1875 by the exertions of Mr. Blanford. Both Mr. Blanford and myself have utilised abnormals for several years for various purposes, as may be seen by a reference to the recent Annual Reports on the Meteorology of India, and to my Hand-book of cyclonic storms of the Bay of Bengal, the greater part of which was prepared in the years 1880-87, but the publication of which was delayed for some time pending the introduction of certain changes in the work of observation in India. In that work I showed how the method of abnormals might be utilised by sailors to warn them of approaching cyclonic storms and gave brief rules to guide them in its use (*vide* pages 42-51). I may add that the Government of India sanctioned the employment of a large temporary staff during the year 1888 in order to tabulate the meteorological data which had been collected by the department during the previous 12 or 13 years and work out daily means of pressure, temperature, rainfall, &c., and these have been utilized since the 1st of January 1889 for the daily preparation of abnormal charts in the Simla Office and for the publication of abnormal data. It is needless to observe that abnormals cannot be used in forecasting weather and storms, until reliable and accurate daily normals have been obtained, and it was not until the year 1888 that a long enough series of observations had been taken at the great majority of our Indian stations to enable satisfactory means and normal data to be derived from these observations.

The preceding statement is made, not from any wish to detract from the value of Mr. Chambers' cyclone investigations, but to place on record the fact that both the Simla and Calcutta offices have for some years utilised the method of abnormals for various purposes (including forecasting at Calcutta and since January 1889 at Simla) and devoted much time and labour to the development of the method—facts which Mr. Chambers does not appear to have been aware of when he prepared this paper.—J. E.

² Indian Meteorological Memoirs, Vol. IV, page 262.

of the Arabian Sea, with regard to the annual oscillatory movement in latitude of the equatorial zone of low pressure. A few remarks are also made on the subject of the origin of cyclones, showing how certain disturbances of the normal meteorological conditions may lead to the formation of an enclosed area of low pressure, and thus give rise to the generation of a cyclone. In the second chapter the daily history of the storm is briefly given, and the importance of the construction of charts showing lines of equal barometric disturbance and abnormal winds is plainly demonstrated. In fact it appears from the evidence herein advanced that, in India, definite indications of the formation and approach of cyclones are usually obtainable from charts of abnormal winds and abnormal pressures *two or three days before* such indications are perceptible in ordinary charts of isobars and wind directions. The great practical importance of this conclusion, in its bearings upon the working of storm-warning systems in the tropics, is self-evident. Indeed, in all countries where, as in India, the normal barometric gradients, and the normal winds are considerable, and where the barometric and anemometric disturbances are, in their incipient stages, relatively small, it is obvious that the earliest and feeblest indications of disturbance must be much obscured by the normal conditions, and can only become clearly perceptible after the latter have been eliminated, which is what is done by the preparation of daily charts of abnormal winds and abnormal pressures.

In the third and last chapter, the results are summarised and discussed, and conclusions are drawn respecting the distortion of the form of the cyclone by the monsoon winds, which are almost identical in character with those obtained from my discussion of the great storm of May-June 1881. In the present case, however, the distortion was much greater than before, because the monsoon winds were stronger and the cyclone winds weaker, the combined effect being, that at a distance of 250 miles from the centre, the resultant winds on the west side of the cyclone blew almost radially towards the centre, while those on the east side blew tangentially, with even a slight inclination outwards from the centre; and the winds on the north side were very weak, while those on the south side were very strong. The provisional rule before given for finding the direction of motion of cyclones in the Arabian Sea in May and June from the direction of the normal wind is now modified as follows:—*The direction of motion of cyclones in the Arabian Sea in May and June is about eight points to the left of the direction towards which the normal monsoon wind blows. This rule is subject to a possible error of two points either way, that is to say, the inclination of the path to the left of the normal wind may vary between six and ten points.*

CHAPTER I.

REMARKS ON THE METEOROLOGY OF THE ARABIAN SEA AND THE ADJACENT PARTS OF THE INDIAN OCEAN.

In the first chapter of my paper on the Arabian Sea cyclone of May and June 1881, I showed, from a discussion of the quarterly charts of meteorological information published by the Hydrographic Department of the Admiralty in 1872, and from a discussion of barometric observations made at Mauritius, Zanzibar, Aden, Bushire and at stations on the west coasts of India and Ceylon, that the equatorial belt of low atmospheric pressure moves north-

ward in the course of the half-year from February to July from about 10° South latitude to about 24° North latitude, and that during the remaining half of the year it gradually returns southward, from latitude 24° North to latitude 10° South. Since that paper was written, a set of monthly weather charts for the Arabian Sea, compiled by Mr. W. L. Dallas, has been published by the Meteorological Department of the Government of India. The information on which these charts are based appears to be hardly sufficient to determine satisfactorily the normal winds, and (more especially) the normal pressures for every part of the Arabian Sea and the adjacent portions of the Indian Ocean, for there are, in some parts of the area, and in some months, considerable discrepancies between the distribution of pressure indicated by the charts and the observed winds drawn on them. They do, however, in a general way, confirm the conclusions arrived at in the first mentioned paper with respect to the movement of the equatorial belt of low pressure. From January to March northerly and north-easterly winds prevail as far south as the equator, and, therefore, the region of low pressure in those months must lie to the southward of the Line. In April the north-easterly winds lose their preponderance in the middle of the ocean near the equator, and are replaced by westerly and south-westerly winds and calms, which indicate the approach from the southward to the neighbourhood of the equator of the equatorial zone of low pressure. In May the winds from the equator to about latitude 7° North are chiefly from the south, south-west, and west directions, while farther to the north between latitudes 7° N and 10° N they are very variable, though northerly winds prevail in the middle portion of the sea between longitudes 64° E and 70° E, thus indicating the presence of a region of low pressure in about latitude 8° N. This area of low pressure is also clearly indicated by the isobars. From June to September the winds are almost invariably from south-westward in every part of the Arabian Sea, and in these months the low pressure lies far to the north over the land. In October, a band of low pressure overlies the eastern part of the Arabian Sea with its axis running along the parallel of about 16° N. In the western half of the Arabian Sea, the winds are chiefly north-easterly as far south as about 11° N latitude and south-westerly between latitude 10° N and the equator. To be in agreement with these winds the axis of the region of low pressure should bend down to about latitude 10° N in the western half of the Arabian Sea, but the isobars drawn over the western part of the chart show no indication of such a distribution of pressure. In November also, a band of low pressure overlies the eastern half of the southern portion of the Arabian Sea. A line drawn through the middle of this region of low pressure, runs from about latitude 11° N on the west coast of India in a west-south-west direction across the sea towards the equator in longitude 50° E. Hence it appears that the axis of the band of low pressure has receded southward on the average about 8° between the middle of October and the middle of November. In December the winds of the Arabian Sea are steadily north-easterly as far south as 3° N latitude, but between this parallel and the equator they are more variable, and the proportion of calms is larger than farther to the northward. Hence it may be inferred that the band of low pressure has, in this month, receded southwards to the neighbourhood of the equator.

Theory of cyclones.—In chapter I of my paper on the Arabian Sea cyclone of May and June 1881, it is shown that the tropical cyclones of the Indian Ocean and its arms—the Bay of Bengal and the Arabian Sea—almost invariably originate in the equatorial belt of low pressure. Now, in accordance with Ferrel's theory of cyclones, the fundamental

condition that must be satisfied before a cyclone can originate, is that the atmosphere overlying some central area should become less dense than that over the external surrounding parts. In order, therefore, to connect the forementioned fact with Ferrel's theory, it is necessary to show how a central area of relatively low atmospheric density may occasionally be formed in the equatorial zone of low pressure. It has already been pointed out that in the middle of May, a trough of relatively low pressure occupies the middle of the Arabian Sea in about latitude 8° N, and that this trough is separated from the low pressure over the land to the north by a ridge of relatively high pressure in about latitude 15° N. The first advance of strong south-west monsoon winds into the Arabian Sea and Northern Indian Ocean seems to take place normally from the south-west corner of it, and these winds bringing the cooler and heavier air of the Southern Indian Ocean to the north of the equator, raise the pressure there, and cause the isobars over that region to assume a tongue-like form, protruding in a north-easterly direction into the Arabian Sea as shown in Mr. Dallas' chart for the month of May. They thus close in on the west side the region of relatively low pressure in the middle of the Arabian Sea. As the season advances, this region of low pressure continues to move northward, and rain eventually begins to fall along the Malabar Coast. The fall of rain in this region cools the air of the lower atmosphere, and gives rise to a tongue of high pressure which pushes itself northward along the Western Ghâts. The region of low pressure in the middle of the sea is thus closed in on its eastern side also. Now if this takes place before the ridge of relatively high pressure to the north of the equatorial minimum is finally broken down by the northward advance of the minimum zone, and by the fall of pressure over the land to the northward, and, therefore, before the setting in of the south-west monsoon wind over the whole of the Arabian Sea, the condition required for the formation of a cyclone in the middle of the Arabian Sea will be fully satisfied, for the air overlying the middle of the sea will then have a lower density than that over the surrounding parts. The weather charts of the Arabian Sea for noon of the 25th and 26th May 1881, forming plates XXVI and XXVII of the Indian Meteorological Memoirs, Vol. IV, No. 8, seem to imply that the Arabian Sea cyclone of May-June 1881 was probably formed in this manner.

There is, however, another way in which a small barometric minimum may occasionally be formed near the west coast of India in the neighbourhood of the Laccadives, where many of the storms which are on record are known to have originated. In the months of April and May, before rain has begun to fall in Southern India, the isobars run almost parallel to the coast, the pressure being lowest over the land and increasing over the sea to a distance of about 300 or 400 miles from land. Now immediately after rain has fallen on the Western Ghâts the pressure rises there, and the isobars over the sea, which before were nearly parallel to the coast, are bent back upon themselves from the southward, as shown by Mr. Dallas' chart for the month of June, thus enclosing near the coast a small region of relatively low pressure which may occasionally be sufficient to initiate a cyclonic movement. The cyclone described in the following paper may possibly have been formed in this manner.

CHAPTER II.

HISTORY OF THE STORM.

Tabular data.—The data from which the history of the storm is gathered are contained in tables VII to XXVI which form the Appendix. Two tables are given for each day. The first contains the information obtained from observations made on land, and the second that collected from ships that were in the Arabian Sea at the time of the storm. Little description of these tables appears to be called for, the headings of the several columns being, for the most part, self-explanatory. A word in explanation of the column headed "Abnormal" is however desirable. The numbers in this column show the deviation of the actual observed pressure at the time of observation from the normal or average pressure for that day of the year. This normal daily pressure has been obtained by proportionate interpolation from the monthly means derived from the observations recorded at the same hour of the day during the five years 1877 to 1881. Great care has been taken in the calculation of the monthly mean normal pressures for each station, so as to eliminate all errors and render the results for different stations rigorously comparable with each other, appropriate interpolation having been made from the observations of surrounding stations, wherever any errors or omissions existed in the original observations. The special value of the results obtained is in great measure due to the care exercised in the calculation of the normal values.

Table XXVII contains the abnormal north and east components of the wind at 10 hours for a considerable number of stations in Western India, for which monthly normal values of the wind components have been worked out. Unfortunately, similar information is not available for stations in other parts of India, where the practice of reducing the wind components has not yet been generally adopted. In Western India, however, where this method has been systematically worked since 1877, satisfactory normal monthly values of the wind components are now available for nearly all the observing stations. The numbers entered in table XXVII are the deviations of the actual wind components observed at 10 hours of the respective dates from the normal monthly wind components of the same hour of the day. It was not considered necessary in this case to interpolate normal values for each day of the year as in the case of the barometric pressure. A refinement of this kind would hardly be appropriate until a longer series of wind observations shall have afforded more accurate values of the normal components than have yet been obtained.

Charts.—These have been prepared for each day from the 4th to the 13th June 1887, inclusive. The broken lines are isobars, drawn for each tenth of an inch of pressure. Over the sea these lines are sometimes to a considerable extent conjectural, but they have always some evidence to rest upon, although it may occasionally be but slight. Over the land, however, the lines are undoubtedly accurate. The wind arrows are drawn so as to represent both the direction of the wind and its force on Beaufort's scale, according to the convention indicated on each chart. The arrows are drawn so that their points indicate the position of the ship or observatory, and they are represented as flying with the wind, and, therefore, pointing in the direction towards which the wind is blowing, not in that from which it comes, as is the case with an ordinary vane. The lines drawn with dots and bars

over the land only, are lines of equal abnormal pressure, or equal deviation from the normal pressures of the day. These are drawn for every half-tenth of an inch above or below the normals, those indicating a pressure above the normal being marked with the positive sign, and those below with the negative. The line of normal pressure is drawn thicker than the rest. From the points of the wind-arrows for almost all stations in Western India dotted lines are drawn in certain definite directions. These dotted lines represent *abnormal* winds, blowing *towards* the points of the wind-arrows, that is *towards* the several stations. The number of dots in each of these dotted lines represents the strength of the abnormal wind, each dot counting as two miles per hour. A line of five dots would, therefore, represent an abnormal wind of 10 miles per hour from the direction in which the line is drawn. These abnormal winds show the extent to which the normal wind of the season must be disturbed in order to produce the actual wind blowing at the time of observation. They, therefore represent the amount of wind disturbance at the time and are directly comparable with the abnormal pressure lines which show the amount of barometric disturbance at the same time. It should be pointed out that the observations at land stations were taken at 10 A.M., while those used for filling in the charts over the sea, are the observations recorded at noon. The pressure values from which the isobars over the land were drawn are the values for noon obtained by proportionate interpolation from the observations recorded at 10 A.M. and 4 P.M., or from those recorded at 10 hours on the same and the following days; corrected for diurnal variation. The lines of equal abnormal pressure, however, and the abnormal winds, represent the abnormal conditions at 10 A.M., not at noon. Before drawing the charts which illustrate this chapter, the barometric and thermometric observations were carefully corrected for index errors, which were in almost all cases determined by comparing the instruments used on board the ships indirectly with the standard instruments of the Colaba Observatory, Bombay. The barometric observations were also reduced to 32° Fahr., and to sea level. They were next curved under each other for verification by intercomparison, and all erroneous observations thus brought to light were eliminated. They were then laid down on charts and all glaringly inconsistent readings were rejected. No attempt has been made to correct the individual wind observations for errors caused by motion of the ship.

DAILY HISTORY OF THE STORM.

4th June 1887.—The chart for this day is the first which shows any definite indication of the formation of the cyclone. The disturbance at this time was so feeble that it is hardly traceable in the ordinary isobaric lines, or in the actual wind directions, but it becomes very evident when the lines of equal barometric disturbance and the abnormal wind-arrows are carefully inspected. The only indication observable in the lines of equal pressure is the widening out of the isobars of 29.7" and 29.8". This widening of the lines did not much affect the wind directions, for nearly all remained of the normal type, but it did affect the strength of the wind, more especially at Malegaon, Poona, Sholapur and Belgaum, where they were much weaker than usual. This is best shown by the abnormal winds which at those stations were all from eastward, with a velocity of ten or more miles per hour. The most definite indication of the commencement of the formation of the cyclone is, however, afforded by the circular form of the southern part of the line of normal pressure which curves round the relatively low pressures at Ratnagiri, Karwar and Belgaum. The

centre of this area of relatively low pressure appears to have been near the coast, somewhat to the south of Ratnagiri, and between that station and Karwar. This inference is supported by the fact that at Karwar the wind was reported to be from south-west and "fresh," and therefore somewhat stronger than usual. It is further supported by the fact, that in the neighbourhood of Karwar, the barometric gradient for south-westerly winds was considerably steeper than usual, the difference of pressure between Ratnagiri and Mangalore being about '07" greater than the normal difference at that time of the year.

On the evening of the 4th June 1887, the *S S Lamport* left Bombay for Suez, and was never again heard of. It is almost certain that she foundered in the cyclone. The evidence afforded by the chart of the 4th shows that she might have been warned of the first indications of the formation of the cyclone, before proceeding to sea.

At Karwar, and to the southward, along the whole of the Malabar Coast, heavy rain had fallen during the preceding twenty-four hours, but to the north of that station, though the skies were generally cloudy, there had been no rain, except at Sholapur. In the western and northern parts of the Arabian Sea, the wind and weather appear to have been normal in character, but in the eastern part of the sea, off Bombay, the winds were light and variable, agreeing in this respect with the small barometric gradients there. To the south of Socotra, in latitude 10°N , the south-west monsoon wind was blowing with full force.

5th June 1887.—The chart for this day shows a very decided development of both the area and the depth of the relative barometric depression. This is indicated very clearly by the lines of equal abnormal barometric pressure, from which it also appears that, on the 5th, the centre of the disturbance was immediately to the west of Ratnagiri, and that the pressure near the centre was now more than a tenth of an inch below the normal. The cyclonic character of the disturbance is very definitely indicated by the abnormal winds, which clearly circulate in a left-handed direction round the centre of the relative depression, and also curve inwards towards that centre. The lines of equal barometric pressure, however, still show very little indication of the formation of the depression, and the directions of the actual winds are not as yet decidedly and consistently cyclonic, like the abnormal winds. Indeed, the formation of a closed area of low pressure of any considerable extent does not yet appear to have taken place, the normal distribution of pressure not having yet been completely over-balanced, but merely modified by the comparatively small disturbance of pressure caused by the early stages of the development of the cyclone. Similarly, the formation of an actual cyclonic whirl over a considerable area does not yet appear to have taken place, the strength of the abnormal winds due to the disturbance not having yet risen sufficiently to over-power the normal winds, and cause an actual cyclonic circulation of any large portion of the lower atmosphere, but only enough to modify them considerably, as regards strength, or direction, or both. During the previous twenty-four hours heavy rain had continued to fall at Karwar, and at nearly all the coast stations to the southward; and light rain had extended further north than on the previous day, *viz.*, to the stations Belgaum, Ratnagiri and Poona, but not to any stations beyond. Heavy rain had also fallen over the sea near Cape Guardafui, and off the east coast of Africa in latitude 7°N and longitude 52°E ., and also between latitudes 6° and 9°N and longitudes 66° and 71°E ., and therefore probably over nearly the whole

of the southern part of the Arabian Sea south of latitude 10°N . In the north-west quarter of the sea no rain was reported.

6th June 1887.—A still further development of the abnormal barometric depression is shown by the chart for this day. The line of lowest abnormal pressure indicates a depression of $\cdot 15''$ against a depression of $\cdot 1''$ on the previous day, and the depression at the centre amounts to nearly two-tenths of an inch. The centre appears to have been a little more to the north than on the 5th. The abnormal winds represented by the short dotted lines, again, indicate decidedly an abnormal cyclonic rotation round the centre of low abnormal pressure, thus confirming the indications afforded by the lines of equal barometric disturbance. But, as on the previous day, the isobars or lines of equal barometric pressure give but little indication of the existence of the cyclonic disturbance. Indeed, the portions of these lines which pass over the land, when taken by themselves, show hardly any indication of it; but, when taken in connection with their continuations over the sea, they do afford some evidence by the sudden southward bend of the lines $29\cdot 6''$ and $29\cdot 7''$, contrasted with the slight northward bend of that of $29\cdot 5''$. This slight indication given by the portions passing over the land, might easily be overlooked in the absence of the continuations of these lines over the sea, and even when taken in combination, there is still no area of low pressure completely enclosed by any of them. Neither do the actual wind directions as yet show any decided cyclonic movement on a large scale.

Heavy rain continued to fall during the previous twenty-four hours along the whole of the coast from Karwar to Cochin. It had also extended much farther northward than on the previous day, it being now reported for the first time from Belgaum, Ratnagiri, Bombay, Poona and Malegaon. Rain was also reported on this day by two ships off the coast of Kathiawar, and also by two in the south-east quarter of the Arabian Sea, but by none in the western half of the Sea.

7th June 1887.—The isobars drawn on the chart for this day show, for the first time, a closed area of low pressure, and the arrows representing the actual winds show, for the first time, a decided cyclonic motion round the centre of low pressure. The cyclone was therefore decidedly formed on this day, with its centre in about latitude $17^{\circ} 20'\text{N}$, and longitude $71^{\circ} 45'\text{E}$. The first indications of the process of formation were, however, given by the abnormal pressure lines, and the abnormal wind-arrows drawn on the chart of the 4th, that is to say, no less than *three days before the actual formation of the large cyclonic whirl*. The portions of the isobars passing over the land, again, show little indication of the existence of the vortex off the coast, but the lines of equal barometric disturbance indicate its existence even more strongly than on the previous day, the line of lowest depression being now that of $\cdot 2''$ against that of $\cdot 15''$ on the 6th. With the continued development of the cyclone the abnormal winds strengthened greatly, especially at Bombay, Poona and Malegaon. The abnormal winds at the stations near the vortex were, it will be observed, all from directions several points to the left of the directions from which the actual winds blew, and it will be noticed that in nearly all cases the position of the vortex is more accurately determined by reckoning its direction, in accordance with the usual rule, from the abnormal wind, rather than from the actual wind. This is a point of considerable importance, because it shows that the position of the vortex is best found by reckoning its direction, not from that of the actual wind, but from that of the

abnormal wind. This result confirms the conclusion to the same effect which I drew from my investigation of the Arabian Sea cyclone of May-June 1881.

The chart shows that the rainfall on this day was chiefly concentrated in the neighbourhood of the cyclone, although it still continued heavy on the Malabar coast, and some ships in the north-west quarter of the Arabian Sea recorded it. In the southern part of the Arabian Sea rain seems to have ceased, or to have become much lighter than on the previous day.

The lowest observed pressure on any ship was 29.466" on the mail steamer *Assam*, at 8 P.M. and at midnight, soon after leaving Bombay on the voyage to Aden. This reading was taken while the *Assam* was on the east side of the cyclone. An almost equally low reading of 29.475" was observed on the *Sumatra* at 10 P.M. on the north-west side of the cyclone. The pressure at the centre was probably much lower than either of these recorded readings, for it is probable that neither vessel was within 50 miles of the centre on this day. At noon, the two steamers *Orion* and *Sumatra* were each about 100 miles to the north-west of the centre of the cyclone. Both report a north-westerly wind at that hour, that is to say, a wind blowing almost straight towards the centre. The course of the former vessel was eastward and that of the latter westward. During the latter half of the day the former experienced a shift of the wind from NW round by N to E S E, while the latter had a steady wind from NW almost the whole of the time. This difference in the observed behaviour of the wind on the two vessels is satisfactorily accounted for by the facts that the former met the cyclone and passed through the northern half of it, while the latter travelled in the same direction as the cyclone, and thus remained on the same side of it in the same position relatively to the centre. The greatest force of the wind observed on the *Orion* was force 7, when the wind was from N, and when the barometer was lowest and reading 29.518". On the *Sumatra* the force of the wind varied from a fresh to a strong breeze. Hence it appears that on the 7th, at a distance of somewhat less than 100 miles from the centre, the intensity of the cyclone was very moderate. It is very evident from the charts of the 4th, 5th, 6th and 7th June that the *Assam* and all the vessels that left Bombay after noon of the 4th, might have been warned of the gradual formation of the cyclone, and with this information they might have shaped their courses so as to avoid it. All in-coming vessels which passed Aden, after noon of the 4th, might also have been warned by telegraph, and by signal at Aden, of the existence of the cyclone, and might, by deviating to the southward, have kept out of danger. The mail steamer *Nizam* which left Aden on the 7th might thus have been saved the delay of three days which was caused by her becoming involved in it, and having to "heave to."

8th June 1887.—The chart of the 8th shows a further remarkable development of the cyclone, and a rapid shifting of the centre to the westward from about latitude $17^{\circ} 20' N$, and longitude $71^{\circ} 45' E$, to about latitude $17^{\circ} 55' N$, and longitude $68^{\circ} 20' E$, through a distance of about 240 miles. The centre must, therefore, have travelled at an average rate of 10 miles per hour. Simultaneously with this increase of intensity and rapid transfer westward, the lines of equal barometric disturbance on land had become arcs of greater circles, enclosing larger areas than before, while retaining nearly the same numerical values, and the abnormal winds had strengthened considerably, not only in the Konkan and the Deccan, but also in Guzerat, Cutch and Lower Sind, thus confirming the abnormal pressure lines in showing that the cyclone was exerting its influence over a very much larger area than

before. It is evident from the form of the lines of equal barometric depression, and from the character of the abnormal winds, that a very good estimate of the position of the centre of the cyclone might have been made from the land observations alone, and the inference that the cyclone had increased in intensity might also have been drawn from them. On the other hand, the isobars over the land give little or no information to this effect, and the indications of cyclonic circulation afforded by the actual winds at land stations are much less definite than those derivable from the abnormal winds, the former showing no decided increase of intensity and no change of the position of the cyclone, while the latter show an increase both of intensity and of area affected, and also indicate the true character of the change of position that had taken place.

The rainfall appears to have been concentrated chiefly in the neighbourhood of the cyclone as on the previous day. Less had fallen on the land to the eastward where the winds were now blowing from land to sea, but on the coast to the south of Ratnagiri, where the winds were from seaward, heavy rain continued. Most of the ships in the south and west of the Arabian Sea outside the storm-field reported no rain. The lowest pressure observed on any vessel on this day was 28·858" on the *Draco*, at 2. A.M., when the wind was strong from west-south-west with thunder, lightning, heavy rain and a high confused sea in which the ship laboured heavily. This vessel reported a gradual backing of the wind from west-south-west at 1 A.M. round by south to south-south-east at midnight, showing that she passed through the southern half of the cyclone while on her way from Aden to Bombay. A very low reading of 28·916" was also observed on the *Assam* at midnight, when the vessel was to the northward of, but not far from, the centre. During the day the barometer had gradually fallen from 29·376" at 4 A.M. to the forementioned reading at midnight, and simultaneously the wind had risen from a "fresh" to a "strong gale," with frequent squalls of hurricane force and driving rain. The wind direction had at the same time gradually backed from south-east to north-east, showing that the vessel was slowly overtaking the cyclone, which was moving in the same westward direction as itself, but at a somewhat slower rate. Shortly before midnight the wind "fell quite light," and half an hour after midnight it was again "blowing with terrific force" from south-east. At 10 P.M. it had been blowing with cyclonic force from north-east. The *Sumatra* was also involved in the cyclone on the 8th while steering westward towards Aden. She reported a gradual fall of the barometer from 29·434" at 2 A.M. to 29·125" at midnight, with a gradual increase of the strength of the wind from a "fresh" breeze to a "violent gale" accompanied by terrific squalls and blinding rain. The direction of the wind changed but slightly from north-west to west. From these facts it appears that the vessel was all the day in advance of the cyclone, but was gradually being overtaken by it. The SS *Akbar* reported a gradual backing of the wind from west at 1 A.M. round by south to south-south-east at 4 P.M. She must, therefore, have crossed the southern half of the cyclone on this, the last day of her voyage to Bombay from the Gulf of Aden. Throughout the day she experienced heavy squalls of wind and rain.

9th June 1887.—The chart for this day shows that the centre of the cyclone had continued to move westward, and that at noon it was in about latitude 18° 30' N, and longitude 65° 20' E. It had, therefore, travelled about 200 miles in the twenty-four hours in a west-north-west direction, at an average rate of 8·3 miles per hour, and therefore apparently at a somewhat slower rate than during the previous day. It does not, however,

appear to have increased in area, but if anything, to have slightly decreased since noon of the 8th, for the isobar of 29'4" now covered a somewhat smaller area than before. The circular form of the lines of equal abnormal pressure over the land still indicates very clearly the existence of the cyclone out at sea, and the further inference that the cyclone had moved farther away from land can also be drawn from these lines alone, for they are, roughly speaking, arcs of circles having a common centre situated farther out to sea, than the common centre of the lines of the previous day, and the numerical values of the lines are smaller than on the 8th. Moreover, this inference is fully confirmed by the abnormal winds at Kurrachee and Bhuj, for these had veered and strengthened considerably during the preceding twenty-four hours, while that at Bombay had remained nearly in the same direction as before, but had decreased slightly in strength. On the other hand the lines of equal barometric pressure over the land afford no apparent evidence of the existence of the cyclone, and the slight evidence of cyclonic circulation given by the actual wind directions at land stations is much less definite than that afforded by the abnormal winds.

The rainfall was, as on the previous day, chiefly confined to the storm-field, and to the western coast of India from Ratnagiri to Cape Comorin.

The lowest pressure observed on this day was 28'86" on the *Lorna Doone* at midnight, when the wind was blowing with hurricane force from north-east. This ship reported a strong gale from north-west at 1 A.M., which veered to north-east, and gradually increased to hurricane force at noon, and continued all day without any abatement. At 1 A.M. of the same day, the *Assam* observed an almost equally low barometer reading of 28'956," with a south-east wind of hurricane force, which gradually veered to south-west at 8 A.M. and decreased in force, while the barometer gradually rose to 29'396" as the storm centre passed away to the west-north-west. The *Sumatra* also observed a gradual rise of the barometer from 29'105" at 2 A.M. to 29'425" at 10 A.M., while the wind backed from west to south, and decreased in force from a strong gale to a moderate gale. The *Giava* reported a rise of the barometer from 29'00" at 1 A.M. with a wind of force 10 from south-south-west, to 29'70" at 9 P.M., with a wind of force 6 from south-south-east. The *Clan Forbes* reported a fresh gale from south-south-west at 1 A.M., which gradually increased to a hurricane from west-south-west at 8 A.M., and continued all day with little or no improvement until 8 P.M. Similarly, the *Oswald* had a moderate gale from west-south-west at 1 A.M., which increased to a hurricane from south-west at 10 A.M., after which the wind moderated somewhat, though it was still blowing very hard from south-south-west at midnight.

10th June 1887.—The chart for this day shows a very rapid increase of the area and of the intensity of the cyclone, corresponding isobars having largely increased in diameter and being now much nearer to each other. The centre had continued to move westward and was now in latitude 19° 10' N and longitude 61° 50' E, having travelled 240 miles during the preceding twenty-four hours at the average rate of 10 miles per hour. The lines of equal abnormal pressure over the land still indicate clearly the existence of the cyclone out at sea, but these have contracted considerably and become arcs of smaller circles than before, though the pressure had generally risen slightly. The contraction of the lines of equal barometric disturbance, taken by itself, would indicate that the centre of the cyclone had approached nearer the land than before, but this inference conflicts with the

evidence afforded by the general rise of pressure, and it is unsupported by the abnormal winds which had, on the whole, veered slightly and become somewhat weaker, thus indicating that the centre had moved farther away towards the north-west, as in fact was the case. On the other hand, the lines of equal barometric pressure over the land give no indication of the continued existence of the cyclone, and the actual winds at land stations afforded very little, if any, indication of it.

Singularly enough there is very little evidence of rain having fallen on this day within the storm-field, but it would not be safe to infer that none fell. Rain was, however, reported by two vessels about 300 miles to the south-west of the storm-centre and by several others at greater distances to the north-east and south-east of it. Light rain also extended on this day into the interior of India to several stations to the north-east of Bombay.

The lowest pressure recorded by any vessel on this day was 29'024" on the *Albany* at midnight, but this was not the lowest reading registered on that vessel. For the barometer continued to fall until 8 A.M. of the following morning, when a pressure of 28'688" was recorded. Throughout the 10th the *Albany* was in the western semicircle of the cyclone, steaming towards Kurrachee. At 6 A.M. she recorded a barometer reading of 29'268" with the wind from north-west, force 5, and a decreasing south-west sea. The barometer fell gradually during the whole of the day to the reading above mentioned at midnight, and the wind varied between NW and N, its greatest recorded force being 7. At 10 P.M., the wind was from north and the sea "inclined to N-E rollers." The *Lorna Doone* reported a hurricane from north-east which continued until 5-30 A.M. when the barometer began to rise. By noon the wind had veered to south, while its force had decreased to a "moderate gale." The *Assam* reported a south-westerly gale during the whole of the day, varying in force from "moderate" to "strong" with a barometer almost stationary at about 29'45," which is accounted for by the fact that the vessel was moving in the same direction as the cyclone. The *Darien* also reported a south-west gale, varying in force from a "hurricane" at 1 A.M. to a "moderate" wind at 8 P.M. The *Nizam* experienced a south-west gale varying from force 6 at 1 A.M., to force 9 at 3 P.M., at which it continued throughout the rest of the day. The *Cian Graham*, which was on her voyage from Bombay* towards Aden, also experienced a strong gale throughout the day, varying in direction between west-south-west and north-west. The *Rothsay*, which was at noon about 400 miles to the south-west of the centre and steaming towards Bombay, reported a steady south-south-west gale, varying in force from "fresh" at 4 A.M., to "heavy" at noon, with a tremendous sea and afterwards increasing in force with terrific squalls, a mountainous sea and very threatening weather.

11th June 1887.—The chart for the 11th shows a still further displacement of the centre of the cyclone towards the west, and perhaps a slight increase of intensity, the area affected by it being now apparently somewhat greater than before. At noon the centre was in about latitude 19° 10' N, and longitude 60° 10' E, and had hence travelled about 110 miles to the west during the preceding twenty-four hours, at an average rate of 4'6 miles per hour, which is only about half the rate of the previous day. The existence of the cyclone out at sea is still feebly indicated by the form of the line of normal pressure which passes through Lower Sind and Guzerat, dividing the region of relatively high pressure over Rajputana from that of relatively low pressure in Lower Sind, Cutch and Kathiawar. Its continued existence is also distinctly shewn by the abnormal winds at Kurrachee, Bhuj,

and Deesa, which still continue to circulate cyclonically round a centre situated to the south-westward. On the contrary, the lines of equal pressure over the land again give no indication of the cyclone, and the actual wind directions at land stations afford no definite evidence of its existence.

Rain appears to have been general over the whole of the Arabian Sea immediately to the southward and eastward of the storm-field, and along the whole of the coast of India from Surat to Cape Comorin. Hail was observed near the centre of the cyclone.

The lowest barometric pressure observed on this day was, as already mentioned, 28·688" on the *Albany* at 8 A.M. when the wind was blowing a strong gale from north, and scud was observed from N-E, N and SW. At 9 A.M. a gradual decrease of the northerly sea and N-E rollers was observed, and at 10 A.M. a south-west swell set in and gradually increased to heavy S-W rollers at noon. At 11 A.M. the wind decreased, but after a dead calm of about 15 minutes, burst out again from south, with hurricane force and violent squalls. Numerous birds and insects flew about the ship during the calm interval. The hurricane from south continued until 5 P.M., when the wind backed to south-east, and the weather began to clear rapidly, and at 7 P.M. "fine clear cloudless weather" was reported. At 8 P.M. the wind had fallen to a moderate breeze from south-east, and the heavy swell had changed its direction from south-west to south. The barometer had at this time risen to 29·234," and an hour later it read 29·291", having risen about six-tenths of an inch since 8 A.M. The *Clan Graham* reported a "strong gale at 1 A.M. which increased to a terrific gale at 8 A.M.," with a "tremendous sea" and "torrents of rain" from a "dull slaty sky." From 10 A.M. to 3 P.M. this ship is said to have been in the centre of the cyclone, but the recorded observations do not support this statement. At 1 P.M. the wind was from north-west, at 3 P.M. it was blowing with the force of a "strong gale," at 6 P.M. it had backed to west with the force of a "fierce gale," and at 8 P.M. it was from west-south-west, at which it continued till midnight with the same force as at 6 P.M. The *Nizam*, to the south of the storm-centre, at a distance of about 250 miles at noon, reported a steady south-west gale all the day, blowing with force 9 up to 6 A.M., and force 10 thereafter, accompanied by "furious squalls" and a "terrific sea." The *Assam* also reported a steady gale all the day, of force 7 to 8, from south-south-west and south-west by south. This ship was at noon about 200 miles to the south-east of the centre. The *Rothsay*, which at noon was about 50 miles farther away from the centre, and between the *Nizam* and the *Assam*, but nearer to the latter, reported a steady gale from south-south-west with "terrific rain squalls" and a "tremendous sea" from 1 A.M. to noon, after which the wind and sea moderated. The *Sumatra*, which at noon was about 250 miles to the east-south-east of the centre, reported a steady south-south-west wind all the day, varying from "strong" at 4 A.M. with a high confused sea, to a "strong breeze" at midnight. The *Lorna Doone*, about 250 miles to the east of the centre, reported at noon a moderate gale from south with a very heavy sea.

12th June 1887.—The chart for this day indicates a continued movement of the centre of the cyclone towards the west, but this is merely an inference from the curvilinear form of the isobars in the western part of the Arabian Sea, for no ship is known to have been very near the centre on the 12th. Besides the evidence afforded by the curvilinear isobars, there is the decided evidence afforded by the four ships, the *Clan Graham*, the *Assam*, the *Nizam* and the *Germania*, all of which were, at noon, on the south side of

the cyclone, and each of which reported a strong south-westerly gale and 'very high sea.' There is also some slight evidence of the influence of the cyclonic circulation at the mouth of the Persian Gulf on this day, for two ships in that neighbourhood reported south-easterly breezes instead of the usual north-westerly winds, and this is what might be expected to result from the continued westerly movement of the cyclone.

The distribution of abnormal pressure in Western India on this day shows no definite evidence of the existence of the cyclone, and the abnormal winds had now become feeble. Hence it might perhaps be inferred that the cyclone had continued to move further away to the westward, as was really the case.

Heavy rain was reported from the south of the storm-field and over the whole of the north-eastern part of the Arabian Sea, and along the whole of the west coast of India.

13th June 1887.—The chart for this day shows no decided evidence of the existence of the cyclone either along the Arabian Coast, or in the Persian Gulf at Bunder Abbas or at Bushire. It is probable, therefore, that the cyclone broke up on reaching Arabia. It is evident from the chart that the disappearance of the cyclone left the south-west monsoon wind in possession of the whole of the Arabian Sea. It also appears that heavy rain continued to fall along the whole of the steamer track between Bombay and Socotra, as well as on the whole of the west coast of India, and it may be mentioned that a chart prepared for the 14th, which is not published herewith, shows that the same conditions as regards wind and rainfall continued on that day too.

Track of the cyclone.—The successive positions of the centre of the cyclone at noon on successive days, and hence the track of the cyclone, have been determined from a consideration of the isobaric lines and the wind directions, obtained from the observations recorded on board ships. The successive positions are given in the following table along with various other data:—

TABLE I.

DATE.	North Latitude at noon.	East Longitude at noon.	Movement in preceding 24 hours.	Rate of movement per hour.	Direction of movement.	Lowest observed pressure.	Corresponding diameter of cyclone.	Corresponding force of wind.	Diameter of isobar of 29.4.	Force of monsoon wind outside isobar of 29.4.
OF CENTRE OF CYCLONE.										
1887.			Miles.	Miles.		Inches.	Miles.	Beaufort's scale.	Miles.	Beaufort's scale.
7th June .	17° 20'	71° 45'	...	...	...	29.47	70	4	107	4.9
8th „ .	17° 55'	68° 20'	240	10	N 82° W	28.86	20	9	220	4.8
9th „ .	18° 30'	65° 20'	200	8.3	N 77° W	28.86	70	12	180	6.6
10th „ .	19° 10'	61° 50'	240	10	N 78° W	29.02	50	7	370	6.2
11th „ .	19° 10'	60° 10'	111	4.6	W	28.69	0	9	420	5.4

The track is represented on Plate LIV by the continuous line joining the dots which indicate the position of the centre each day at noon. The circles represent the isobars of 29.4" on successive days, and show the gradual growth of the cyclone from day to day. Possibly the circle for the 9th is smaller than it ought to be, since all the rest show a gradual increase from day to day while this one shows a slight decrease, and therefore a breach of continuity in the otherwise gradual expansion of the area of the cyclone. The

“somewhat slower rate of movement of the centre of the cyclone from the 8th to 9th, as compared with the rate on the preceding and following days, may also be unreal, but it is noteworthy that the apparently slower rate of movement occurs at the same time as the apparent decrease of area. The mean force of the monsoon wind outside the isobar of 29·5” gradually increased up to 6·6 on the 9th, and thereafter gradually decreased. On each of the charts for the 4th to the 10th attempts have been made to fix the position of the centre of the cyclone from the land observations alone. Two methods have been employed for this purpose. First, a centre has been chosen in such a position that it shall form as nearly as possible a common centre to all the lines of equal abnormal pressure, and shall accord with the individual barometric abnormalities near the centre when these are available. The centre so fixed is marked with the letter B. Second, lines have been drawn inclined at angles of 50° to the left of the more prominent abnormal wind-arrows of the stations near the centre, and a point occupying a middle position among the several near intersections of these lines has then been selected. The point so selected is marked with the letter W. Finally the mean of the two positions marked B and W has been taken and marked with a small circle and the letter C. This point is accepted as the most probable position of the centre of the disturbance, so far as can be inferred from the land observations alone. It will be observed that the corresponding points B and W are not very far apart during the earlier stages of the disturbance, when the cyclone was not many hundred miles away from land, and that so long as the positions B and W do not differ widely, or in other words, so long as the centre fixed by the abnormal pressure lines is approximately confirmed by that fixed by the abnormal winds, the mean position marked C agrees closely with the actual position of the centre of the cyclone as determined from observations taken on board ship. The following are the successive daily positions of the centre of the cyclone at 10 A.M., as estimated from the land observations alone, from the 4th to the 9th June inclusive, after which the place of the centre can no longer be definitely determined by that method.

Track of the Cyclone as estimated from land observations alone.

TABLE II.

DATE.	North Latitude.	East Longitude.	MOVEMENT IN MILES.		Direction.	Force of monsoon wind outside isobar of 29·5”.
			Daily.	Hourly.		
4th	16° 20'	73° 40'	...	...	...	3·9
5th	16° 30'	72° 40'	60	2·5	WNW	4·3
6th	17° 0'	72° 40'	30	1·2	N	3·9
7th	17° 30'	71° 20'	90	3·7	WNW	4·9
8th	17° 40'	68° 50'	150	6·2	W	4·8
9th	17° 40'	65° 40'	210	8·7	W	6·6

The successive positions thus determined show very clearly the gradual acceleration of the rate at which the cyclone moved westward.

On the 7th, 8th and 9th the successive positions of the centre have been deter-

mined by two methods, first by estimation from the land observations alone, and second by estimation from ship observations. The differences between the positions so determined are for the respective dates 30, 50 and 60 miles. These distances become respectively 40, 18 and 57 miles, after making allowance for the change in the position of the cyclone between 10 A.M. and noon. Hence it appears that when the indications afforded at the land stations by the abnormal pressure lines and the abnormal winds support each other, the position of the cyclone centre at sea may be found from them alone with considerable accuracy.

But the great advantage of drawing lines of equal abnormal pressure and plotting out the abnormal winds, is that indications of the approach of a cyclonic disturbance are thus obtained two or three days earlier than by the ordinary methods of merely drawing lines of equal pressure and plotting out the actual wind directions. Moreover, the information thus obtained is much more definite in character than that given by the ordinary methods. The truth of these assertions is very clearly illustrated by the following statements of the inferences that might have been drawn from the abnormal winds and abnormal pressure lines, and the inferences actually drawn and published daily by the Meteorological Office at Simla during the days when the storm under discussion was in existence.

Inferences drawn from land observations only¹—

	From <i>abnormal</i> winds and pressures.	From <i>actual</i> winds and pressures.
4th June.	A small cyclonic disturbance has formed on the Malabar Coast. At 10 A.M. this morning the centre was about 50 miles south-south-east of Ratnagiri.	<i>Nil.</i>
5th do.	The small cyclonic disturbance noticed yesterday has intensified considerably. The centre is now about 50 miles to the south-west of Ratnagiri, and apparently moving slowly towards the west-north-west.	<i>Nil.</i>
6th do.	The cyclonic disturbance noticed yesterday and the day before has developed, still further. The centre is now about 40 miles to the west of Ratnagiri, having apparently moved slowly northwards during the past twenty-four hours.	<i>Nil.</i>
7th do.	The cyclone has continued to develop during the past 24 hours. The centre of the disturbance has moved farther out to sea in a west-north-west direction, and is now in about latitude $17\frac{1}{2}^{\circ}$ N. longitude $71\frac{1}{4}^{\circ}$ E.	"The winds in Western India show cyclonic circulation over and in the neighbourhood of the slight depression in the Bombay Coast districts. It is not clearly or strongly marked."

¹ It should be noted that the two series of inferences given above were drawn up under entirely different conditions and are not fairly comparable. The series on the right hand were drawn up by the Simla Meteorological Office at the time of the occurrence of the storm and at a period in the history of the Department when nothing had been published respecting the conditions under which cyclonic storms in the Arabian Sea are formed and developed, and when there was a special officer at Bombay entrusted with the duty of warning the Bombay coast ports of approaching cyclones.

The other series of inferences appear to have been drawn up about two years after the occurrence of the storm, after a systematic examination of all the available data respecting the storm had been collected. Those who are acquainted with the difficulties of forecasting weather and the occurrence of storms are aware that it is a comparatively easy task after complete data have been collected to work back from a storm to its earliest feeble probable indications; whereas it is always a, more or less, difficult matter to infer at the time from these feeble indications that a storm will gradually be formed and develop into a cyclone or not, as the case may be. The experience of the past two years has shown several cases in which the abnormalities indicated the commencement and partial development of cyclonic disturbances which did not advance to the stage of cyclonic storms of sufficient intensity to warrant the hoisting of storm signals and the probable consequent interference with trade which the hoisting of storm signals at large ports necessarily causes. Hence valuable as the method of abnormalities is, it by no means affords certain indications in the earliest stages of cyclonic storms or necessarily justifies the hoisting of a warning or danger signal during their incipient stages.

From *abnormal* winds and pressures.From *actual* winds and pressures.

8th June. The cyclone has continued to move out to sea since yesterday. The centre is now in latitude $18\frac{1}{2}^{\circ}$ N. and longitude 69° E. It has moved westward about 150 miles during the past 24 hours, and its rate of motion is increasing. Although the storm has moved much further out to sea, the barometer in Western India has remained nearly stationary. Hence it may be inferred that the cyclone is rapidly enlarging, and its intensity increasing.

"Winds continue to show the same unusual features at the Bombay stations. They are from north-east in Guzerat, and from east and south-east at Bombay, and the neighbouring coast stations, thus indicating feeble in-draught to a centre off the Bombay Coast. There are no signs of the intensification of the cyclonic circulation."

9th do. The cyclone is still moving westward. The centre is now in about latitude $17\frac{1}{2}^{\circ}$ N. longitude $65\frac{1}{2}^{\circ}$ E., it having moved at the increased rate of about 200 miles in the past 24 hours. The barometer has risen rapidly throughout Western India. Hence it appears that the cyclone is probably of about the same area and intensity as yesterday.

"The depression off the Bombay coast has disappeared, and has apparently almost filled up. The wind directions are somewhat irregular in Bombay, and show that the weather has been, and probably is still, squally along that coast, but that there has been no violent cyclonic circulation on the large scale in the Arabian Sea off the Bombay Coast."

10th do. The cyclone has probably continued to move westward. Its area must now be very large, since strong abnormal winds continue throughout the whole of the coast districts from Bombay to Kurrachee, and the pressure is still abnormally low there.

Nil.

11th do. The cyclone appears to have continued its march westward. It is still producing easterly abnormal winds at Bhuj and Kurrachee but it now no longer affects Bombay. The pressure remains slightly below the normal from Surat to Kurrachee thus confirming the abnormal winds of that neighbourhood in their indication of the continued existence of the cyclone.

Nil.

12th do. There now remain no indications of the cyclone. It has therefore either continued its westward motion, or has broken up.

Nil.

The important bearing of these results on the working of storm warning systems, more especially in the tropics, is self evident; for it will be observed that, in the present instance, the existence of the storm might have been detected by the method of abnormals no less than three days before it was discovered by the method of actuals. Other similar instances are on record. For instance, in the case of the small cyclone of November 7th to 10th 1888, which crossed the coast of Kathiawar into Kutch along a north-easterly course, the abnormals of the 7th give definite indications of the approach of the cyclone, whereas the actuals show no sufficiently decided indication to justify the issue of warning signals until the 9th, two days later. Evidence to this effect was given before the Court of enquiry into the loss of the S. S. *Vaiturna* which foundered in this cyclone causing the loss of nearly 800 lives. Similarly, in the case of the cyclone of the 8th to

the 12th June 1885, which formed near the Laccadives, and afterwards travelled in a north-west direction, the abnormal wind-arrows and the abnormal pressure lines afford very definite indications of the gradual formation of the disturbance during three or four days preceding the 8th, and also afford the means of tracing the gradual movement of the storm from day to day up to the 12th, whereas the lines of equal pressure and the actual wind directions afford little or no definite indication of it. Indeed, this storm is mentioned in the daily reports of the Simla Meteorological Office only on the 8th and 9th. There is little doubt, therefore, that in every case of a storm approaching, or forming near, the land, the abnormal pressure lines and the abnormal winds would afford the means of detecting the existence of the disturbance two or three days before the isobaric lines and the actual winds show any decided indication of it.

It follows as a necessary conclusion from these results that a cyclonic disturbance is not a phenomenon which supersedes and entirely displaces the normal meteorological conditions, but that it is one which is superposed upon them, the actual meteorological conditions at any moment during the progress of the cyclone being the result of the combined action of the normal and abnormal states.

CHAPTER III.

DISCUSSION OF RESULTS.

In order to determine the average characteristics of the cyclone, the data shown in the following Table have been extracted from the rough charts on which the noon observations were first entered. The angles between the radius of the cyclone and the wind were measured from the charts with a protractor, and the gradients were determined by first measuring the distance apart of the two nearest isobars with a scale of nautical miles, and afterwards converting the distances into the differences of pressure per 60 nautical miles. The barometric pressures entered in column 10 are the pressures read from the storm-charts. The normal pressures of column 11 were obtained by interpolation from Mr. Dallas's pressure charts of the Arabian Sea for June. The observations entered in this table are those recorded at noon on ships that were at the time not more than 500 miles distant from the centre of the cyclone, and on which the barometer, as indicated by the isobars, had fallen not less than two-tenths of an inch below the normal pressure of the time of year.

TABLE III.

DATE.	Latitude of ship (North).	Longitude of ship (East).	WIND.		Distance from centre of cyclone.	Octant of cyclone.	Angle between radius and wind.	Barometric gradient per 60 nautical miles.	Barometric pressure.	Normal barometric pressure.	Abnormal.
			Direction.	Force.							
				Miles.					Inches.	Inches.	Inch.
7th June .	18° 17'	70° 31'	NW	6	110	NW	9	'033	29'54	29'75	—'21
" "	18° 0'	70° 19'	W	4	115	NW	—26	'033	'54	'76	—'22
" "	16° 19'	73° 12'	SW	2	115	SE	94	'067	'55	'78	—'23
" "	16° 6'	73° 1'	SSW	4	120	SE	65	'067	'56	'77	—'21
" "	19° 32'	71° 46'	NE	5	150	N	47	'027	'54	'74	—'20

TABLE III—continued.

DATE.	Latitude of ship (North).	Longitude of ship (East).	WIND.		Distance from centre of cyclone.	Octant of cyclone.	Angle between radius and wind.	Barometric gradient per 50 nautical miles.	Barometric pressure.	Normal barometric pressure.	Abnormal.
			Direction.	Force.							
				Miles.					Inches.	Inches.	Inch.
7th June	21° 16'	69° 21'	WNW	4	310	NW	—35	·026	29·52	29·73	—·21
" "	18° 54'	72° 49'	SE	4	115	NE	96	·020	·51	·76	—·25
8th June	18° 54'	72° 49'	SE	5	300	E	53	·030	·52	·75	—·23
" "	18° 15'	62° 54'	W	5	355	W	—3	·046	·59	·81	—·22
" "	20° 40'	64° 30'	ESE	1	315	NW	167	·026	·54	·74	—·20
" "	16° 17'	62° 38'	SW	4	390	W	—28	·014	·62	·84	—·22
" "	18° 54'	72° 49'	SE	4	300	E	57	·028	·53	·75	—·22
" "	17° 15'	62° 22'	WSW	5	395	W	—16	·014	·62	·83	—·21
" "	16° 16'	62° 8'	WSW	4	425	W	—6	·014	·63	·84	—·21
" "	17° 41'	67° 41'	W	9	50	W	24	·085	·80	·32	—·48
" "	18° 13'	69° 20'	SSE	6	70	E	78	·080	·34	·78	—·44
" "	18° 34'	71° 14'	S	6	195	E	101	·048	·46	·74	—·28
" "	18° 34'	71° 27'	SWbyS	6	210	E	132	·048	·47	·74	—·27
" "	18° 11'	71° 51'	SW	8	230	E	140	·050	·48	·74	—·26
" "	18° 29'	64° 12'	WNW	8	275	W	16	·045	·54	·80	—·26
" "	16° 33'	63° 49'	SSW	8	310	W	—49	·050	·57	·84	—·27
9th June	16° 3'	58° 30'	SW	6	480	W	—25	·017	·58	·81	—·23
" "	18° 57'	66° 16'	S	5	65	E	109	·172	·36	·78	—·42
" "	18° 9'	66° 55'	SSW	7	70	SE	84	·172	·37	·79	—·42
" "	19° 48'	64° 33'	NE	12	100	NW	77	·060	·40	·76	—·36
" "	17° 2'	65° 5'	SSW	12	115	S	12	·067	·42	·85	—·43
" "	16° 48'	64° 49'	SW	12	155	S	32	·067	·47	·83	—·36
" "	17° 0'	62° 49'	SW	8	200	SW	—11	·060	·50	·83	—·33
" "	17° 50'	68° 22'	SSE	8	205	E	54	·045	·51	·81	—·30
" "	17° 32'	60° 2'	W	6	355	W	12	·015	·54	·79	—·25
" "	16° 41'	59° 29'	WSW	6	410	W	—5	·018	·56	·82	—·26
10th June	17° 59'	68° 9'	WSW	5	425	E	145	·041	·58	·78	—·20
" "	16° 32'	67° 19'	WSW	6	415	SE	129	·048	·59	·82	—·23
" "	19° 49'	60° 35'	N	7	80	NW	60	·172	·19	·75	—·56
" "	19° 52'	63° 53'	S	7	150	E	107	·092	·32	·76	—·44
" "	17° 16'	62° 40'	SW	12	150	SE	68	·109	·33	·83	—·50
" "	18° 10'	64° 32'	SbyW	9	200	SE	78	·100	·40	·80	—·40
" "	18° 43'	65° 28'	SSW	6	250	E	104	·083	·46	·79	—·33
" "	16° 6'	59° 19'	SW	9	275	SW	7	·085	·50	·81	—·31
" "	16° 58'	58° 20'	W	9	280	SW	35	·075	·51	·79	—·28

THE ARABIAN SEA CYCLONE OF

TABLE III—concluded.

DATE.	Latitude of ship (North).	Longitude of ship (East).	Wind.		Distance from centre of cyclone.	Octant of cyclone.	Angle between radius and wind.	Barometric gradient per 50 nautical miles.	Barometric pressure.	Normal barometric pressure.	Abnormal.
			Direction.	Force.							
				Miles.					Inches.	Inches.	Inches.
10th June	17° 34'	66° 38'	SW	7	335	E	114	'046	29'54	29'81	—'27
" "	16° 36'	66° 0'	SW	9	335	SE	100	'050	'54	'82	—'28
" "	16° 5'	57° 29'	WSW	8	360	SW	13	'033	'55	'80	—'25
" "	14° 39'	58° 13'	SSW	9	395	SW	—13	'046	'58	'83	—'25
11th June	18° 20'	66° 19'	WSW	6	410	E	148	'033	'57	'80	—'23
" "	18° 40'	66° 40'	SSW	4	430	E	102	'032	'58	'78	—'20
" "	17° 34'	66° 31'	SW	6	435	E	119	'034	'60	'81	—'21
" "	19° 4'	60° 25'	S	12	20	SE	71	'600	28'80	'76	—'96
" "	16° 55'	57° 40'	NW	12	225	SW	89	'075	29'41	'78	—'37
" "	17° 10'	62° 30'	SSW	8	210	SE	71	'120	'47	'83	—'36
" "	15° 38'	58° 57'	SW	10	260	S	27	'100	'48	'82	—'34
" "	17° 57'	63° 22'	SSW	6	230	SE	91	'120	'50	'81	—'31
" "	19° 50'	64° 2'	S	7	265	E	100	'085	'49	'75	—'26
" "	15° 50'	56° 18'	WSW	8	340	SW	19	'033	'51	'79	—'28
" "	16° 6'	61° 52'	SSW	7	240	SE	52	'035	'51	'84	—'33
" "	15° 10'	56° 0'	SWbyW	6	390	SW	12	'033	'54	'80	—'26
" "	12° 31'	57° 1'	SSW	8	500	SW	—2	'023	'62	'87	—'25

For the purpose of calculating average values of the gradient, of the angle between the radius of the cyclone and the wind, of the distance of the ship from the cyclone centre, of the barometric pressure, of the abnormal pressure and of the force of the wind, the data in the above table have been classified in three different ways; first, in accordance with gradient, second, in accordance with distance from the centre, and third, in accordance with the octant of the cyclone, certain arbitrary limits of gradient and of distance having been selected to form the boundary of each class.

TABLE IV.—Average values of certain cyclone elements.

Limits.	CLASSIFIED WITH RESPECT TO THE GRADIENT.				CLASSIFIED WITH RESPECT TO THE DISTANCE FROM THE CENTRE OF THE CYCLONE.								CLASSIFIED WITH RESPECT TO THE OCTANT OF THE CYCLONE.							
	Limits of Gradient in inches.				Limits of distance from centre in miles.								Octant of cyclone.							
	0.00 to 0.10	0.10 to 0.20	0.20 to 0.30	0.30 to 0.40	0 to 49	50 to 99	100 to 149	150 to 199	200 to 299	300 to 399	400 to 500		N	NE	E	SE	S	SW	W	NW
Gradient in inches	'035	'073	'110	'172	'600	'126	'050	'069	'075	'033	'030	'037	'030	'029	'044	'089	'078	'051	'032	'058
Angle between radius and wind in degrees.	51°	52°	69°	85°	71°	71°	47°	71°	66°	10°	69°	47°	66°	104°	83°	24°	17°	—8°	43°	
Distance from centre in miles.	323	179	210	72	30	67	313	161	237	346	437	150	115	367	308	177	349	344	172	
Pressure in inches	29° 550	29° 453	29° 426	29° 307	28° 800	29° 316	29° 503	29° 474	29° 489	29° 551	29° 390	29° 540	29° 510	29° 488	29° 482	29° 437	29° 524	29° 537	29° 455	
Abnormal pressure in inches.	—'240	—'346	—'383	—'465	—'960	—'464	—'373	—'356	—'314	—'241	—'333	—'300	—'250	—'285	—'326	—'377	—'287	—'261	—'293	
Force observed, Beaufort's scale.	5'9	8'2	9'0	6'3	12'0	6'8	6'3	8'4	8'1	6'0	5'7	5'0	4'0	6'0	7'0	11'3	8'6	6'1	5'7	
Number of observations	33	15	5	3	1	5	7	5	15	15	9	1	1	10	10	3	9	10	6	

The average results of all the observations of Table III except one, which cannot appropriately be combined with the rest, because of the very excessive steepness of the gradient, are as follows :—

Mean barometric gradient in inches per 60 nautical miles	·058
Mean angle between radius and wind	54°·5
Mean distance from centre of cyclone in miles	261
Mean pressure in inches	29·501
Mean abnormal pressure in inches	—·292
Mean force of wind (Beaufort's scale)	6·8
Corresponding mean velocity of wind in miles per hour	39

The averages, obtained by arranging the observations in accordance with distance from the centre, show that at a distance of 161 miles the force was 8·4, while at 437 miles it was 5·7, that is to say, a mean increase of 2·7 in force corresponds to a mean decrease of distance of 276 miles, and therefore between these limits, the average rate of increase, as the centre is approached, is one unit of force per 100 miles. With this rate of increase, the mean forces in the different octants at their respective mean distances from the centre have been reduced to what they would become at a uniform distance of 250 miles from the centre. No change, however, has been made in the corresponding angles of inclination of the wind to the radius, because the observations do not afford any satisfactory evidence of a tolerably regular change of angle with change of distance merely. These results are given in the following Table.

TABLE V.

Octant.	Distance from centre.	Force on Beaufort's scale.	Corresponding velocity in miles per hour.	Corresponding direction.	Angle between radius and wind.
	Miles.				
N	250	4·0	23	N 47° E	47°
NE	250	2·7	17	S 39° E	96°
E	250	6·2	35	S 14° W	104°
SE	250	6·6	38	S 38° W	83°
S	250	10·6	71	S 24° W	24°
SW	250	9·4	59	S 62° W	17°
W	250	7·0	40	S 82° W	—8°
NW	250	4·9	28	N 3° W	42°

The figures in the last column of this Table are represented graphically by Fig. 1, Plate LV, which shows that the bearing of the centre of the cyclone, reckoned from the direction of the wind to the left when standing with the back to the wind, varied in the different octants of the cyclone in a systematic way from 104° in the east octant to —8° in the west octant, the numbers gradually decreasing from the former to the latter, and gradually increasing from the latter to the former. In the north-east and east octants the wind actually blew to some extent outwards from the centre, since the wind-arrows there are inclined outwards from the tangent to the circle drawn round the centre of the cyclone, at angles of 6° and 14° respectively. On the other hand, in the south-west and west octants the wind blew almost straight towards the centre of the cyclone. The fourth column of numbers in the above table shows that the velocity of the wind also varied in a systematic way from 71 miles per hour in the south octant to 17 miles per hour in the north-east octant, the numbers gradually decreasing from the south octant round by east, and also round by west, to the north-east octant. These systematic variations are exactly

similar to those found in the case of the Arabian Sea storm of May and June 1881, and are doubtless due to the same cause, *viz.*, the combination of the ordinary south-west monsoon wind with the cyclone wind proper. To show that this is the case, the method adopted in the discussion of the cyclone of June 1881 has been applied to the present case, and the results given in the following table have thereby been deduced:—

TABLE VI.

Octant of cyclone.	N	N-E	E	S-E	S	S-W	W	N-W	Mean.
North component of actual wind.	+15.7	-13.2	-33.9	-29.9	-64.9	-27.7	-5.6	+28.0	-16.4
East component of actual wind.	+16.8	+10.7	-8.5	-23.4	-28.9	-52.1	-39.6	-1.5	-15.8
North component of cyclone wind.	+32.1	+3.2	-17.5	-13.5	-48.5	-11.3	+10.8	+44.4	...
East component of cyclone wind.	+32.6	+26.5	+7.3	-7.6	-13.1	-36.3	-23.8	+14.3	...
Radial component of cyclone wind.	+32.1	+21.0	+7.3	+4.1	+48.5	+33.7	+23.8	+21.3	+24.0
Tangential component of cyclone wind.	+32.6	+16.4	+17.5	+14.9	+13.1	+17.7	+10.8	+41.5	+20.6
North component of mean cyclone wind.	+24.0	+2.2	-20.6	-31.3	-24.0	-2.2	+20.6	+31.5	...
East component of mean cyclone wind.	+20.6	+31.5	+24.0	+2.2	-20.6	-31.5	-24.0	-2.2	...
North component of mean cyclone wind and mean monsoon wind combined.	+7.6	-14.2	-37.0	-47.9	-40.4	-18.6	+4.2	+15.1	...
East component of mean cyclone wind and mean monsoon wind combined.	+4.8	+15.7	+8.2	-13.6	-36.4	-47.3	-39.8	-18.0	...
Corresponding resultant velocity.	9.0	21.2	37.9	49.8	54.4	50.8	40.0	23.5	...
Corresponding resultant direction.	N 32° E	S 48° E	S 13° E	S 16° W	S 42° W	S 69° W	N 84° W	N 50° W	...
Corresponding angle between radius and wind.	32°	87°	77°	71°	42°	24°	6°	5°	...

The average north and east components are given in the last column. These are equivalent to a resultant monsoon wind of 22.8 miles per hour, or of force 4.0, from the direction S 44° W. The subtraction of the mean north component from each of the numbers in the first line of the table gives the numbers in the third line; and the subtraction of the mean east component from the numbers in the second line gives those in the fourth line. These two lines of numbers represent the wind that is left after eliminating the mean monsoon wind. They, therefore, include the symmetrical portions of the cyclone proper, and all the irregularities of the original observations. In the fifth and sixth lines of the table, the north and east components given in the third and fourth lines are converted into radial and tangential components; and in the last column, the means are taken. These are, a mean radial component of 24.0 miles per hour and a mean tangential component of 20.6 miles per hour, which are equivalent to a resultant wind of 31.6 miles per hour, or of force 5.6, in a direction inclined to the radius at an angle of 41°. In the seventh and eighth lines of the table, the equivalent north and east components of this mean cyclone wind are given for each octant of the cyclone; and by adding respectively to these values the north and east components of the mean monsoon wind, the numbers in the ninth and tenth lines of the table are obtained; and these, converted into their equivalent resultant winds, give the results in the eleventh and twelfth lines. In the

thirteenth line, the angles included between these winds and the radius are given, and finally, the results of the last three lines are represented graphically by Fig. 2, Plate LV, for comparison with Fig. 1 of the same plate, which is drawn from the actual observations. It will be observed that on the whole Fig. 2 agrees remarkably well with Fig. 1, and differs from it only to such an extent as might be expected from the irregularities in the observations, which are all included in Fig. 1, but all excluded from Fig. 2, by the method of calculation. - The latter, therefore, represents the general characteristics of the cyclone better than the former, and affords a very complete and simple explanation of the absence of symmetry in the actual observed winds of the cyclone; showing that the differences on the different sides are due to the superposition on the cyclone wind of a monsoon wind, which inclines the cyclone winds on the west side more towards the centre, but inclines those on the opposite, or east side, farther away from the centre, while it strengthens the cyclone winds on the south side by combining with them, and weakens those on the north side by opposing them, without much changing their directions. These results are entirely in accordance with those obtained from the discussion of the storm of May-June 1881, though in the present case the differences on opposite sides of the cyclone, both as regards wind velocity and inclination to the radius, are much greater than in the former storm. Three conditions combine to produce these greater amounts of distortion in the form of the present cyclone: first, the combined monsoon wind was stronger than before, which is what might be expected from the fact that the storm occurred later in the season, when the normal monsoon is stronger; second, the cyclone wind proper was itself less strong than in the previous storm; and, third, the average results refer to a greater distance from the centre, *viz.*, to a distance of 250 miles in the present instance, against one of 150 miles in the former. There is no doubt that in the present cyclone the conditions at the same distance from the centre, *viz.*, at 150 miles instead of at 250 miles, would differ less from the former results than those here given. The fact that these large differences on different sides of the cyclone have been found to exist, confirms in a very emphatic manner the inference drawn from the former case, that no uniform rule for finding the bearing of the centre of a cyclone in the Arabian Sea is directly applicable to the observed winds in all the octants of the cyclone; but the further fact that these differences vary in a systematic way in accordance with the law of simple mechanical composition of the normal monsoon wind and the symmetrical cyclone wind, as was also the case in the cyclone of May-June 1881, shows that the distorting influence of the monsoon wind on the cyclone wind can readily be eliminated, and when this has been done, the rule for finding the bearing of the centre can be applied with confidence that it will lead to accurate results. The method of eliminating the effect of the monsoon wind and thus finding the symmetrical cyclone wind and thence the true bearing of the centre was fully explained in the former paper.¹ It is not necessary therefore to repeat it here.

In the discussion of the Arabian Sea cyclone of May-June 1881 it was pointed out that there appeared to be an orderly relation between the direction and velocity of the monsoon wind that combines with the cyclone wind and the direction and velocity of motion of the storm centre. In the present instance this relation is not fully confirmed, for although the rate of motion of the centre of the cyclone along its path appears to have varied, as in the former case, in proportion to the strength of the monsoon wind, the direction of motion was not inclined at the same angle to the left of the monsoon wind.

¹ Indian Meteorological Memoirs, Vol. IV, No. 8, p. 351.

In the present case, the mean monsoon wind was blowing towards N 44° E, and the mean path of the storm centre between the 7th and 12th, the days when the position of the centre was first and last determined, was towards N 80° W. The path was, therefore, inclined to the left of the monsoon wind at a mean angle of 124° . In the case of the cyclone of 1881 the combined monsoon wind was blowing towards N 21° E, and the path was towards N 50° W, hence the angle of inclination of the path to the left of the monsoon wind was 71° . The mean of the two results is $97\frac{1}{2}^{\circ}$, that is, the mean path is nearly at right angles to the direction of the combined monsoon wind. The great difference between the two results however, *viz.*, 53° , shows that the supposed constant difference between the direction of the path and that of the monsoon wind does not hold good. The hypothesis of a constant relation of this simple character must, therefore, be discarded.

In the cyclone of May-June 1881 hail was observed on more than one ship. In the present cyclone it was observed on one vessel only, the S S *Albany*, at 7 A.M. on the 11th June, when she was very near the centre and when the remark "Squally, with hail and lightning" appears in the log. If this is accepted as an accurate observation, and there seems no reason for rejecting it, more especially as it agrees with similar observations made near the centre of the cyclone of May-June 1881, it follows, as in the former case, that the vertical thickness of the cyclone on that day must have been more than 22,000 feet.

One of the conclusions drawn from the investigation of the cyclone of May-June 1881, was that a valuable indication to a ship at sea of the existence of a cyclone was afforded by the direction of the swell, which usually comes from a direction several points to the right of the direction from which the wind blows. In the present cyclone few ships have recorded the direction of the swell at the time when they were well within the storm-field, but the log of the *Albany*, a ship which, as already stated, passed through the centre, is very instructive in this respect. At 1 P.M. of the 10th, while the wind was blowing from north with force 7, the remark "Sea inclined to NE rollers" is entered, clearly showing that the heavy swell was then from a direction four points to the right of the wind. At 5 P.M., with the wind still from N, the remark "Sea increasing at NNE" is entered, showing that the sea was still from a direction to the right of the wind. At 9 A.M. on the 11th, when the vessel was very near the centre of the cyclone, with the wind still from N, the remark "Gradual decrease of northerly sea and NE rollers" is entered; and at 10 A.M. a "SW swell" is recorded without any change of wind direction. At 11 A.M. the remark "Wind and sea decreasing, SW swell increasing" is entered, while at noon, when the wind had suddenly gone round to S, and was blowing with hurricane force, the remark, "Heavy SW rollers" appears. These remarks show conclusively that as the cyclone passed from east to west over the ship, the NE swell gradually decreased, and was succeeded by a SW swell, while the wind from N gradually decreased, and changed suddenly to S. It is interesting to notice that the change in the direction of the swell preceded, and thus gave warning of the change in the direction of the wind. At 8 P.M., when the wind was between S and SE, a "Very heavy swell from S" is recorded, the swell still coming from a direction to the right of the wind. The log of this ship affords very strong confirmation, therefore, of the conclusion that in any part of a cyclone in the Arabian Sea, the swell comes from a direction several points to the right of the wind.

APPENDIX.

TABLE VII.—10 A.M., 4th June 1887.

STATION.	Barometer.	Change in twenty- four hours.	Abnormal.	WIND		Thermometer.	Relative humid- ity.	Cloud.	Rain- fall.	Remarks on the weather at 10 A.M.
				Direction.	VELOCITY.					
					At 10 A.M.						Mean of day.
	"	"	"		Miles per hour.	Miles per hour.	°	Per cent.	0 to 10	"
Aden . .	29.749	—'008	...	SSW	...	4	91.9	69	1	Nil.
Bushire . .	'645	+ '025	...	NW	...	5	90.8	67	2	Nil.
Kurrachee . .	'651	+ '032	—'051	WSW	23	27	87.5	65	2	Nil. Fine weather with passing clouds.
Bhuj . .	'661	+ '007	—'006	W	22	20	91.0	48	0	Nil. Blue sky.
Rajkot . .	'682	+ '014	—'014	SSW	5	4	92.0	46	2	Nil. Cloudy.
Surat . .	'741	—'050	—'010	SW	M*	...	94.5	49	6	Nil. Fine weather with passing clouds.
Bombay . .	'774	—'036	—'019	WNW	8	8	87.4	69	2	0.01 Ditto ditto.
Ratnagiri . .	'779	—'039	—'030	SW	12	7	87.5	64	4	0.03 Sultry.
Karwar . .	'818	—'028	—'018	SW	F*	...	75.1	95	10	6.34 Heavy rain.
Mangalore . .	'891	—'001	+ '037	SSW	4	3	76.4	93	10	1.04 Overcast.
Calicut . .	'913	+ '019	+ '030	Calm	0	5	76.6	91	10	0.36 Dark gloomy weather.
Cochin . .	'943	+ '011	+ '037	SW	L*	...	78.0	86	10	1.33 Overcast.
Colombo . .	'937	—'004	...	SSW	...	14	81.5	75	8	0.06 Fine.
Galle . .	'945	—'011	...	W	14	7	80.5	91	5	Nil. Rough sea.
Jacobabad . .	'523	+ '040	—'043	SE	7	4	98.2	37	0	Nil. Blue sky.
Hyderabad (Sind)	'568	+ '056	—'026	SW	24	23	90.8	51	0	Nil. Do.
Neemuch . .	'706	+ '037	+ '056	WNW	...	...	92.1	49	0	Nil. Do.
Deesa . .	'694	+ '034	+ '012	SSW	19	24	88.9	50	7	Nil. Cloudy.
Indore . .	'677	—'018	—'003	W	10	8	89.3	45	0	Nil. Blue sky.
Akola . .	'723	—'012	+ '024	WNW	13	11	92.9	39	5	Nil. Cloudy.
Malegaon . .	'720	—'028	+ '012	SW	6	9	89.9	41	1	Nil. Do.
Poona . .	'764	—'043	—'008	SW	5	12	87.2	52	3	Nil. Do.
Sholapur . .	'738	—'029	—'023	WSW	5	10	89.5	46	4	0.54 Do.
Belgaum . .	'781	—'022	—'044	SSW	9	14	78.3	70	7	0.07 Fine.
Bellary . .	'791	—'020	+ '003	NE	...	5	87.8	56	5	0.21
Bangalore . .	'876	—'003	+ '048	W	...	5	76.7	74	4	Nil. Fine.
Salem . .	'855	—'018	+ '003	W	...	3	84.0	72	4	Nil. Do.

* Abbreviations :—L, Light wind ; M, Moderate wind ; F, Fresh wind ; S, Strong wind ; H, Heavy wind ; V, Violent wind or hurricane.

THE ARABIAN SEA CYCLONE OF

TABLE VIII.—4th June 1887.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND		REMARKS.
				Direction.	Force.	
<i>S. S. Akbar.</i>	1 A.M.	...	...	S	...	2 A.M. to 4 A.M. Moderate and variable breeze.
	5 A.M.	...	...	SSW	...	Fresh breeze, fine and clear. Beam sea.
	Noon	29.768	...	SSW	...	Ditto ditto.
	4 P.M.	...	...	SSW	...	Lat. 14° 35' N, Long. 54° 3' E. Course N 24° E. Distance 258 miles. Moderate breeze.
	8 P.M.	...	...	WSW	...	Ditto.
	4 A.M.	29.861	76.8	W	...	Frequent squalls with heavy rain.
<i>S. S. Colaba.</i>	8 A.M.	29.904	75.8	WNW	...	Moderate breeze and cloudy. Frequent heavy rain squalls.
	Noon	29.929	77.8	NW by W	...	Moderate breeze and cloudy. Rain squalls occasionally.
	4 P.M.	29.844	79.8	W	...	Lat. 8° 56' N, Long. 46° 45' E. Course variable. Distance 155 miles. Moderate breeze and overcast.
	8 P.M.	29.917	78.8	WNW	...	Moderate breeze and cloudy. Frequent squalls.
	Midnight	29.862	80.8	WNW	...	Light breeze and fine. Moderate swell.
	1 A.M.	...	...	Variable	...	Light variable winds and cloudy.
<i>S. S. Congo.</i>	4 A.M.	29.807	...	Do.	...	Ditto ditto.
	Noon	29.807	...	Do.	...	Ditto ditto.
	8 P.M.	29.807	...	Variable	...	Lat. 18° 1' N, Long. 66° 26' E. Course N 71° E. Distance 213 miles. Light variable winds and cloudy.
	1 A.M.	...	...	...	...	1 A.M. to 4 A.M. Moderate breeze and cloudy.
<i>S. S. Draco.</i>	6 A.M.	...	...	SSW	...	Fresh breeze.
	Noon	...	...	SSW	...	Lat. 16° 12' N, Long. 57° 56' E. Course N 24° E. Distance 215 miles. Fresh breeze and fine clear weather.
	Midnight	...	...	...	...	From 8 P.M. fresh breeze and heavy SW swell. Ship rolling heavily and shipping water fore and aft.
	2 P.M.	29.700	84.2	SW	8	Near Aden. Moderate weather.
<i>S. S. Giacca.</i>	5 P.M.	29.750	84.2	Calm	...	Ditto ditto.
	9 P.M.	29.700	83.4	Calm	...	Ditto ditto.
	1 A.M.	...	...	S	3	Moderate breeze and fine weather.
<i>S. S. Kangra.</i>	4 A.M.	29.685	84.8	S	3	Ditto ditto.
	8 A.M.	29.716	84.8	SSW	3	Ditto ditto.
	Noon	29.713	85.8	SSW	3	Ditto ditto.
	1 P.M.	...	...	SW	4	Lat. 47° 56' N, Long. 57° 43' E. Course various. Distance 246 miles.
	4 P.M.	29.618	87.8	SW	4	Moderate breeze and fine.
	8 P.M.	29.643	86.8	SW	4	Ditto ditto.
	Midnight	29.633	85.8	SW	4	Ditto ditto.
	1 A.M.	...	...	SE to SW	2 to 4	1 A.M. to 4 A.M. Fine weather and rain squalls.
	5 A.M.	...	...	S to E	2	

TABLE VIII.—4th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND		REMARKS.
				Direction.	Force.	
<i>S. S. Kohinur</i> —contd.	8 A.M.	...	...	S to E	3	Fresh increasing wind and overcast sky.
	Noon	...	...	S to E	4	Lat. $15^{\circ} 10' N$, Long. $73^{\circ} 41' E$. Distance 225 miles. Sea moderate. Rainy and squally; sky overcast.
	3 P.M.	...	...	SSW	4 to 5	Sea moderate.
	5 P.M.	...	...	SSW	4 to 5	Swell from SW.
	6 P.M.	...	...	S	4 to 5	
	8 P.M.	...	...	S	4 to 5	Moderate breeze and cloudy with passing rain squalls.
	Midnight	...	...	S	4 to 5	Heavy squally weather and much rain.
<i>S. S. Regulus</i>	4 A.M.	29.762	85.0	WSW	...	Calms and light westerly winds with fine clear weather.
	Noon.	29.762	88.0	Calm	...	Lat. $18^{\circ} 46' N$, Long. $72^{\circ} 24' E$. Course N $79^{\circ} E$. Distance 238 miles.
<i>S. S. Britannia</i>	1 A.M.	...	...	SW to WSW	3	Moderate breeze and cloudy with constant rain.
	4 A.M.	...	70.4	SW to WSW	3	Similar weather with heavy squalls.
	5 A.M.	...	...	WSW	3	
	8 A.M.	29.888	74.4	WSW	3	Smart breeze and overcast dry weather.
	11 A.M.	...	...	WSW	3	Moderate breeze and cloudy.
	Noon	29.928	78.4	WSW	3	Lat. $7^{\circ} 6' N$, Long. $70^{\circ} 31' E$. Course S $82^{\circ} W$. Distance 211 miles. Fine weather. Light head sea.
	4 P.M.	29.858	76.4	WSW	3	Smart breeze and fine.
	8 P.M.	29.898	76.4	WSW	3	Similar weather and hazy sky.
	Midnight	...	75.4	WSW	3	Moderate head swell.
<i>S. S. Hydaspes</i>	4 A.M.	29.864	79.9	SW	2	At Colombo. Light wind and fine cloudy weather.
	8 A.M.	29.921	80.9	SW	2	Ditto ditto.
	Noon	29.921	80.9	SW	2	Ditto ditto.
	4 P.M.	29.933	79.9	SW	2	Light wind and overcast with occasional passing showers of rain.
	8 P.M.	29.943	79.9	SW	2	
	Midnight	29.929	77.9	SW	2	Moderate wind and cloudy. Ship pitching at times to head sea.
<i>S. S. Assyria</i>	1 A.M.	...	...	WSW	...	
	2.25 A.M.	...	...	WSW	...	Thick fog.
	4 A.M.	29.615	78.5	WSW	...	Moderate wind and south-westerly swell with hazy weather.
	8 A.M.	29.615	80.5	WSW	...	Moderate breeze and very foggy.
	Noon	29.605	84.5	WSW	...	At Gwadur. Fog taking off at 10.50 A.M.
	4 P.M.	29.475	84.5	WSW	...	Moderate breeze and swell with fine weather.
	8 P.M.	29.525	82.5	WSW	...	Ditto ditto.
	Midnight	29.535	84.5	WSW	...	Light head breeze and fine, with heavy south-westerly swell.
<i>S. S. Bancoora</i>	4 A.M.	29.851	81.0	Variable	2	Thick and rainy, south-westerly swell.
	Noon	29.941	81.0	Westerly	2	Lat. $11^{\circ} 36' N$, Long. $75^{\circ} 29' E$. Cloudy with occasional rain.

THE ARABIAN SEA CYCLONE OF

TABLE VIII.—4th June 1887—concluded.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Bancoora</i> —contd.	8 P.M.	...	...	...	5	Squally and threatening south-westerly swell increasing.
	Midnight	30.020	81.0	W	5	Squally and overcast and raining, south-westerly swell increasing.
<i>S. S. Clan Matheson</i>	4 A.M.	29.727	87.0	W	2	Very light airs. Sky overcast.
	8 A.M.	29.744	88.0	W	1	
	Noon	29.748	94.0	S	1	Lat. 13° 9' N, Long. 43° 40' E. Very sultry;—sea smooth.
	4 P.M.	29.639	94.0	N	2	
	8 P.M.	29.687	92.0	E	2	
	Midnight	29.727	87.0	E	3	Light to moderate and clear.
<i>S. S. Fumua</i>	4 A.M.	29.931	75.0	WSW	5	Fresh head wind and sea, with squalls of rain; sky overcast.
	8 A.M.	29.928	76.0	WSW	4	Ditto ditto.
	Noon	29.926	77.0	WSW	5	Lat. 8° 3' N, Long. 74° 51' E. Distance 263 miles. Moderate head wind with dull cloudy weather. Squalls with rain at intervals.
	4 P.M.	29.921	79.0	W by N	2	
	8 P.M.	29.978	76.0	W by N	3	Light wind and fine weather.
	Midnight	29.908	76.0	W by N	4	Moderate wind and cloudy.
<i>S. S. Kerbela</i>	5 A.M.	...	...	W	2	At Bombay.
	7 P.M.	...	...	W	2	Moderate breeze and fine clear weather.
	8 A.M.	29.721	90.9	W	2	
	Midnight	29.691	88.9	W	2	Light breeze and cloudy.
<i>S. S. Manora</i>	3 A.M.	...	...	...	...	Hard squall with heavy rain.
	4 A.M.	29.797	82.0	SW by W	6	
	8 A.M.	29.813	83.0	WSW	6	
	Noon	29.813	84.0	SW	6	Lat. 10° 0' N, Long. 50° 11' E. Distance 277 miles. Increasing wind and sea. Ship labouring heavily.
	4 P.M.	29.741	84.0	WSW	5	Fresh to strong monsoon. High sea.
	8 P.M.	29.764	83.0	SW	6	Strong monsoon and high sea.
	Midnight	29.782	80.0	SW	6	Strong wind. High and confused sea.
<i>S. S. Mecca</i>	4 A.M.	29.704	...	...	...	Fresh wind and fine.
	8 A.M.	29.714	...	...	...	Fresh monsoon gale with a high breaking sea.
	Noon	29.754	...	SW to WSW	...	Lat. 9° 21' N, Long. 52° 7' E. Distance 124 miles. Same weather. Sea increasing.
	4 P.M.	29.614	...	...	...	Strong monsoon gale with a very high sea.
	8 P.M.	29.654	...	...	...	
	Midnight	29.714	...	...	...	Strong monsoon gale with a very confused sea.
<i>S. S. Navarino</i>	4 A.M.	29.698	...	S	2	Fine.
	8 A.M.	29.748	96.0	S	1	
	Noon	29.788	98.0	Calm	...	Lat. 12° 17' N, Long. 48° 40' E. Distance 222 miles.
	4 P.M.	29.728	98.0	SW	7	
	8 P.M.	29.748	...	ESE	1	
	Midnight	29.748	...	ESE	3	Clear.

TABLE IX.—10 A.M., 5th June 1887.

STATION.	Barometer.	Change in twenty- four hours.	Abnormal.	WIND		Thermo- meter.	Rela- tive humi- dity.	Cloud.	Rain- fall.	Remarks on the weather at 10 A.M.
				Direction.	VELOCITY.					
					At 10 A.M.	Mean of day.				
	"	"	"		Miles per hour.	Miles per hour. 3	°	Per cent.	0 to 10	"
Aden . . .	29.758	+ .009	...	NE	...	...	93.9	163	1	Nil.
Bushire . . .	.544	— .001	...	SW	...	...	90.8	74	...	Nil.
Kurrachee . . .	.615	+ .004	— .042	*SW	23	19	88.0	59	1	Nil.
Bhuj . . .	.635	— .026	— .028	SW	17	13	91.2	46	0	Nil.
Rajkot . . .	.642	— .040	— .051	SSW	7	6	93.6	42	1	0.33
Surat . . .	.686	— .055	— .062	NNW	M*	...	92.5	51	4	Nil.
Bombay . . .	.695	— .079	— .096	SSW	8	8	86.6	73	7	Nil.
Ratnagiri . . .	.705	— .074	— .102	S	14	10	84.4	75	8	0.13
Karwar . . .	.780	— .038	— .056	SW	F*	...	77.6	92	10	4.45
Mangalore . . .	.849	— .042	— .005	SSW	8	6	83.0	81	10	1.10
Calicut . . .	.830	— .029	+ .007	Calm	...	11	77.6	91	10	1.33
Cochin . . .	.946	+ .003	+ .040	SE	L*	...	75.0	90	10	1.73
Colombo . . .	.917	— .020	...	SW	...	13	82.5	75	7	0.66
Galle . . .	.921	— .024	...	WSW	14	13	80.0	91	5	0.30
Jacobabad . . .	.488	— .035	— .073	ENE	4	5	97.1	39	0	Nil.
Hyderabad (Sind)	.607	+ .039	+ .017	SW	22	14	90.8	45	0	Nil.
Neemuch . . .	.618	— .088	— .029	W	...	...	92.6	50	0	Nil.
Deesa . . .	.646	— .048	— .032	SW	10	12	91.9	45	0	Nil.
Indore . . .	.590	— .087	— .088	NW	8	7	93.8	32	0	Nil.
Akola . . .	.662	— .061	— .035	NW	7	6	92.7	39	9	Nil.
Malegaon . . .	.653	— .067	— .053	SE	3	7	88.9	46	10	0.01
Poona . . .	.689	— .075	— .082	E	11	7	86.3	54	5	0.96
Sholapur . . .	.738	0	— .022	S	8	9	84.0	59	7	0.05
Belgaum . . .	.757	— .024	— .067	S	38	21	72.3	86	10	0.16
Bellary . . .	.780	— .011	— .008	SW	...	11	84.5	58	8	Nil.
Bangalore . . .	.866	— .010	+ .038	SW	...	7	75.7	73	6	Nil.
Salem . . .	.861	+ .006	+ .009	SW	...	3	84.5	68	4	1.10

* For abbreviations see foot-note in page 419.

TABLE X.—5th June 1887.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	WIND		REMARKS.
				Direction.	Force.	
S. S. Akbar . . .	4 A.M.	...	...	SW	...	Fresh breeze. Beam sea. Ship rolling heavily. Ditto ditto. Lat. 15° 40' N. Long. 58° 24' E. Course N, 75° 40' E. Distance 260 miles. Fresh breeze. Beam sea. Ship rolling heavily.
	Noon	29.748	...	SW	...	
	4 P.M.	...	...	* WSW	...	
	Midnight	...	...	WSW	...	

THE ARABIAN SEA CYCLONE OF

TABLE X.—5th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Chanda</i>	4 A.M.	29.813	85.0	Variable	...	Light variable wind. Overcast sky with light passing showers.
	8 A.M.	29.833	84.0	Variable	...	
	Noon	29.833	85.0	Variable	...	At Aleppi. Light breeze and overcast. Rainy appearance.
	3 P.M.	...	...	Variable	...	Light breeze and raining.
	8 P.M.	29.843	83.0	Variable	...	Light breeze and westerly swell. Light rain.
<i>S. S. Clan Forbes</i>	Midnight	29.843	82.0	Variable	...	Light variable wind and clear weather with passing shower of rain.
	1 A.M.	...	...	E	...	Light wind and fine clear weather.
	4 A.M.	29.732	89.5	ESE	...	Ditto ditto.
	8 A.M.	29.732	89.5	SW	...	Very light wind and fine weather. Southerly swell increasing.
	Noon	29.732	89.5	SW	...	Lat. 14° 1' N, Long. 50° 30' E. Course N 73° E. Distance 217 miles.
	4 P.M.	...	...	Variable	...	Light wind and clear weather. Southerly swell.
	8 P.M.	29.702	85.5	SSW	...	Ditto ditto.
	Midnight	29.702	85.5	SSW	...	Ditto ditto.
	4 P.M.	29.732	93.5	Variable	...	
	6 P.M.	...	...	SSW	...	
<i>S. S. Colaba</i>	8 P.M.	29.702	85.5	SSW	...	Moderate wind and heavy south-westerly swell. Ship rolling heavily and shipping water.
	Midnight	29.702	85.5	SSW	...	Strong wind. Heavy increasing sea. Ship rolling badly and shipping much water.
	2 A.M.	...	...	W	...	Heavy squall of wind and rain.
	4 A.M.	29.850	77.8	WSW	...	Strong breeze and high sea. Shipping water amid ship.
	8 A.M.	29.843	78.8	W	...	Moderate breeze and frequent heavy rain squalls. Strong westerly swell.
	Noon	29.860	80.8	WSW	...	Lat. 14° 26' N, Long. 74° 54' E. Course N 24° W. Distance 164 miles. Moderate breeze and cloudy.
	4 P.M.	29.790	80.8	Variable	...	Moderate breeze and overcast. Frequent squalls. Wind very unsteady.
	6.30 P.M.	...	...	...	...	Very heavy squall from WSW.
	8 P.M.	29.795	78.8	WSW	...	Strong wind with frequent heavy squalls from westward.
	10 P.M.	...	...	...	...	Heavy sea shipping water fore and aft.
<i>S. S. Congo</i>	Midnight	29.799	80.8	WSW	...	Moderate breeze and sea. Weather cloudy and squally.
	4 A.M.	...	...	Variable	...	Light variable wind and cloudy.
	8 A.M.	29.807	...	...	...	
	11 A.M.	...	...	...	...	Moderate breeze and cloudy weather.
<i>S. S. Cuba</i>	Noon	29.657	...	...	...	Near Bombay. Course N 75° E. Distance 208 miles.
	4 P.M.	29.707	...	...	...	At 7 P.M. heavy rain with thunder and lightning.
	8 P.M.	29.585	84.6	SW	...	Lat. 24° 35' N, Long. 66° 55' E. Course S 6° W. Distance 213 miles.
	Midnight	29.595	84.6	SW	...	Moderate breeze and clear with heavy beam sea. Ship rolling very heavily.
						Ditto ditto.
						Light breeze and clear. Ship rolling heavily.

TABLE X.—5th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	Wind		REMARKS.
				Direction.	Force.	
<i>S. S. Deekan</i>	4 A.M.	...	79.5	WSW	3 to 4	Moderate monsoon and cloudy sky. Ship pitching to west-south-westerly swell.
	6 A.M.	...	...	W	4	
	8 A.M.	...	79.5	W	4	Moderate wind and overcast. Squally weather.
	9.30 A.M.	...	...	...	...	Thick squally weather with rain.
	11 A.M.	...	...	...	...	Weather clearing.
	Noon	...	78.5	W	4	Lat. 8° 21' N, Long. 76° 51' E. Course various. Distance 196 miles. Moderate breeze and overcast with passing squalls of rain.
	4 P.M.	29.968	79.5	W	2	
	6 P.M.	...	...	Calm	...	
	8 P.M.	29.950	78.5	...	...	Light airs and overcast rainy weather. High north-westerly swell.
<i>S. S. Draco</i>	Midnight	29.888	79.5	...	5	Fresh breeze and overcast rainy weather.
	2 A.M.	...	...	WSW	...	Fresh breeze and cloudy. Heavy SW swell. Ship rolling heavily. Shipping water fore and aft.
	8 A.M.	...	...	...	...	Strong wind and high confused sea. Shipping water fore and aft.
	Noon	29.718	...	...	...	Ditto " ditto Lat. 16° 26' N, Long. 69° 28' E. Course N 86° E. Distance 207 miles.
	8 P.M.	...	...	...	...	Less wind and sea.
<i>S. S. Giava</i>	Midnight	...	...	...	...	Moderate breeze and cloudy.
	1 A.M.	29.800	82.4	...	...	
	5 A.M.	29.750	82.4	Calm	...	
	9 A.M.	29.800	84.2	...	...	
	Noon	...	...	...	...	Lat. 13° 32' N, Long. 51° 7' E. Course N 76° E. Distance 238 miles.
	4 P.M.	29.700	82.4	SW	...	
	5 P.M.	29.700	80.6	SSW	...	
<i>S. S. Henry Bolckow</i>	9 P.M.	29.752	80.6	S	...	Strong wind. Rain squall. High sea.
	11 A.M.	...	...	Calm	...	Fine clear weather.
	9 A.M.	29.563	95.5	...	...	At Bunder Abbas.
	3 P.M.	...	...	Calm	...	
<i>S. S. Java</i>	Midnight	...	...	SE	...	Light breeze and fine weather.
	4 A.M.	...	...	...	...	Light air and calm with fine clear weather. At Bunder Abbas.
	8 P.M.	29.527	88.1	Calm	...	Fine clear weather.
<i>S. S. Kangra</i>	Midnight	29.527	88.1	...	...	Light fog.
	4 A.M.	29.601	86.8	SW	3	Moderate breeze and fine.
	8 A.M.	29.643	89.8	SW	3	Ditto ditto.
	Noon	29.643	89.8	SW	3	Ditto ditto.
	4 P.M.	29.563	93.8	SW	3	Lat. 20° 36' N, Long. 60° 38' E. Course N 51° E. Distance 239 miles. Moderate breeze and fine.
	8 P.M.	29.558	87.8	SW	3	Ditto ditto.
	Midnight	29.568	87.8	SW	3	Ditto ditto.

THE ARABIAN SEA CYCLONE OF

TABLE X.—5th June 1887—continued.

NAME OF VESSEL.	Hour.	Baromettr.	Thermo- meter.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Kohinur</i>	1 A.M.	...	...	WSW	...	Heavy squall with rain.
	5 A.M.	...	...	SSE	...	Ditto ditto.
	Noon.	...	...	Variable	...	Lat. 12° 10' N, Long. 75° 2' E. Course various.
	3-20 P.M.	...	...	Variable	2 to 6	Distance 201 miles. Fine weather.
	12 P.M.	...	...	Variable	2 to 3	Wind varying from SSW to WSW. Dirty squally weather with heavy sea running and heavy surf on the beach.
<i>S. S. Nurjahan</i>	5 P.M.	...	...	SW	4	Heavy rain.
	8 P.M.	29.897	82.5	W	4	Near Galle. Moderate swell.
	Midnight	29.927	85.5	WSW	4	Light airs and clear weather.
<i>S. S. Oswald</i>	2 A.M.	...	...	E	...	Light breeze and fine weather.
	4 A.M.	29.748	87.1	...	...	
	8 A.M.	29.779	90.1	ESE	...	Light airs and fine clear weather.
	Noon	29.769	90.1	...	...	Lat. 13° 34' N, Long. 50° 48' E. Course N. 70° E. Distance 222 miles. Light breeze and southerly swell.
	1 P.M.	...	...	S	...	
	4 P.M.	29.718	87.1	S	...	Moderate breeze at 4-45 P.M.
	8 P.M.	29.742	86.4	S	...	Fresh and cloudy.
	Midnight	29.753	85.1	S	...	Strong wind and heavy sea. Ship rolling heavily and shipping water fore and aft.
<i>S. S. Panama</i>	4 A.M.	...	...	SW	...	Strong wind and sea. Vessel shipping large quantities of water on deck.
	Noon	...	...	SW	...	Lat. 15° 43' N, Long. 61° 1' E. Course E by N ½ N. Distance 216 miles.
	4 P.M.	...	...	SW	...	Strong breeze and cloudy till midnight.
<i>S. S. Pemba</i>	2 A.M.	...	...	SW	...	At Kurrachee. Moderate breeze and fine.
	1 P.M.	...	...	SW	...	Fresh breeze and fine weather.
	4 P.M.	29.561	89.0	WSW	...	Left for Bombay at 3 P.M.
	8 P.M.	29.631	85.0	WSW	...	Fresh breeze and fine. Moderate swell.
	Midnight	29.571	86.0	W by S	...	At 11 P.M. fresh breeze and fine clear weather. Hazy horizon. Moderate swell.
<i>S. S. Rockliff</i>	2 A.M.	...	...	Calm	...	Clear. Sea smooth.
	9 A.M.	...	...	ENE	...	
	Noon	...	...	ENE	...	Lat. 13° 34' N, Long. 48° 22' E. Course N 75½° E. Distance 215 miles.
	2 P.M.	...	...	SW	...	At 1 P.M. light breeze and clear. Moderate sea.
<i>S. S. Rothsay</i>	Noon	29.723	97.3	S	...	Lat. 12° 44' N, Long. 45° 24' E. Course E. Distance 220 miles. Steady breeze and fine weather.
	4 P.M.	...	...	E	...	Light east wind.
	Midnight	...	...	E	...	Light airs and smooth sea.
<i>S. S. Victoria</i>	1 P.M.	...	...	WSW	...	Near Bombay. Light wind with a high sea.
	Midnight	...	...	W	...	SW swell and cloudy.
<i>S. S. Britannia</i>	1 A.M.	...	...	WSW	2	
	3 A.M.	...	...	WSW	2	Moderate breeze and cloudy.

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TABLE X.—5th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	Wind		REMARKS.
				Direction.	Force.	
<i>S. S. Britannia—contd.</i>	4 A.M.	...	72.4	WSW	2	Heavy rain squalls with vivid lightning.
	8 A.M.	29.888	74.4	WSW	2	Moderate breeze and cloudy.
	Noon	29.848	78.4	WSW	2	Lat. 6° 58' N, Long. 66° 57' E. Course S. 88° W. Distance 213 miles. Moderate breeze and squally with rain.
	4 P.M.	29.788	74.4	WSW	2	Smart breeze with heavy squalls of wind and rain.
	5 P.M.	...	...	WSW	3	
	8 P.M.	29.848	76.4	WSW	3	Smart breeze. Cloudy. Moderate head sea.
	Midnight	...	74.4	WSW	3	Smart breeze and fine weather.
<i>S. S. Clan Graham</i>	Noon	...	...	...	...	Lat. 38° 51' N, Long. 72° 49' E.
	1 P.M.	...	...	SW	...	
	4 P.M.	29.594	92.8	...	...	Moderate wind and fine weather. Moderate SW swell.
	6 P.M.	...	...	W	...	Moderate wind. Dull cloudy weather. High SW swell. Vessel pitching heavily.
	7 P.M.	...	...	NNW	...	
	8 P.M.	29.607	87.8	...	...	
	Midnight	29.652	89.8	...	...	At 11 P.M. fresh breeze. Cloudy and overcast. High head swell.
<i>S. S. Hydaspes</i>	4 A.M.	29.536	78.9	SW	...	Moderate wind and fine weather with passing clouds.
	8 A.M.	29.893	79.9	SW	...	Moderate wind and fine.
	Noon	29.818	81.9	SW	...	Lat. 7° 17' N, Long. 76° 59' E. Course various. Distance 174 miles. Moderate wind and fair weather. Ship pitching to head sea.
	1 P.M.	...	...	NW	3	
	4 P.M.	29.831	80.9	W	...	Moderate wind and fine. Passing squalls of rain.
	8 P.M.	29.881	80.9	W	...	Moderate wind and fine cloudy weather. Ship pitching to head sea.
	Midnight	29.886	78.9	...	...	Moderate wind with heavy squalls of wind and rain.
<i>S. S. Assyria</i>	4 A.M.	29.535	84.5	WSW	...	Light wind. West south-westerly swell and fine clear weather.
	8 A.M.	29.525	90.5	WSW	...	Moderate breeze and fine weather.
	9 A.M.	...	...	ENE	...	
	Noon	29.575	103.5	ENE	...	Lat. 23° 59' N, Long. 58° 58' E. Course SW. by S. Distance 226 miles. Light breeze and north-easterly swell.
	8 P.M.	...	...	...	...	Light airs and calm up to midnight.
<i>S. S. Bancoora</i>	4 A.M.	29.953	80.0	WSW	6 to 4	Violent squalls and rain. Heavy SW sea.
	8 A.M.	29.918	82.0	WSW	4	Squally, with threatening appearance. Heavy SW sea.
	Noon	29.903	84.0	WSW	4	Squalls moderating. Heavy SW sea.
	4 P.M.	29.845	83.0	SW	6	Lat. 18° 23' N, Long. 24° 27' E. Strong wind and thick rainy weather. Heavy SW sea.
	8 P.M.	29.843	84.0	SW	6	Heavy squalls and thick rainy weather. Heavy SW sea.
	Midnight	29.925	83.0	SW	6	Ditto ditto.
<i>S. S. Clan Matheson</i>	4 A.M.	29.737	87.0	SE	2	
	8 A.M.	29.735	88.0	SE	2	Light wind.
	Noon	29.739	90.0	SE	2	Lat. 42° 28' N, Long. 46° 54' E. Sea smooth.

THE ARABIAN SEA CYCLONE OF

TABLE X.—5th June 1887—concluded.

NAME OF VESSEL.	HOUR.	Barometer.	Thermometer.	WIND		REMARKS.
				Direction.	Force.	
<i>S. S. Clan Matheson</i> —concl.	2 P.M.	29.719	90.0	N	2	
	8 P.M.	29.724	88.0	N	2	Light and variable winds.
	Midnight	29.727	87.0	SE	4	Moderate wind and clear. Sea smooth.
<i>S. S. Jumna</i>	4 A.M.	29.888	76.0	WSW	3	Moderate to light wind, with strong NW squall and rain.
	8 A.M.	29.878	80.0	WSW	3	Moderate wind and overcast.
	Noon	29.896	77.0	WSW	3	Lat. 8° 16' N., Long. 70° 26' E. Distance 263 miles. Moderate wind with squally appearance.
	4 P.M.	29.848	80.0	W	4	Moderate head wind and sea. Overcast.
	8 P.M.	29.828	76.0	W	4	Fresh wind and sea. Squally with rain.
	Midnight	29.852	75.0	W	5	Fresh wind and fine. Moderate sea.
<i>S. S. Kerbela</i>	1 A.M.	...	...	Calm	...	Fine clear weather.
	4 A.M.	29.671	86.9	Calm	...	
	8 A.M.	29.671	87.9	...	...	light airs. Fine cloudy weather.
	Noon	29.671	86.9	Calm	...	Lat. 20° 25' N., Long. 70° 44' E. Course N 30° W. Distance 149 miles. Swell from SW.
	1 P.M.	...	...	Westerly	3	
	4 P.M.	29.591	86.9	Westerly	3	At 3 P.M. moderate breeze and fine clear weather.
	8 P.M.	29.613	87.9	Westerly	3	Light breeze and fine clear weather.
	Midnight	29.621	85.9	Westerly	3	Moderate breeze and fine.
<i>S. S. Manora</i>	4 A.M.	29.782	80.0	SW by W	5 to 6	Strong monsoon. High confused sea.
	8 A.M.	29.737	82.0	WSW	5 to 6	Ditto ditto.
	Noon	29.712	83.0	WSW	5 to 6	Lat. 12° 57' N., Long. 55° 24' E. Distance 295 miles. Ditto ditto.
	4 P.M.	29.714	83.0	WSW	3	Fresh breeze and clear.
	8 P.M.	29.709	85.0	SW	2	Moderate to light monsoon.
	Midnight	29.667	82.0	SSW	6	Moderate to hard gale and high sea.
<i>S. S. Mecca</i>	4 A.M.	29.844	...	...	...	Hard gale with high-breaking sea.
	8 A.M.	29.754	...	...	...	
	Noon	29.854	...	WSW	...	Lat. 7° 29' N., Long. 52° 34' E. Distance 215 miles. Wind not so strong. High confused sea.
	4 P.M.	29.704	...	...	...	Strong wind and high sea with occasional rain squalls.
	8 P.M.	29.734	...	...	...	Rain abated.
	Midnight	29.844	...	...	...	Strong breeze with heavy sea.
<i>S. S. Navarino</i>	2 A.M.	29.698	...	SSE	3	Fine.
	8 A.M.	29.768	86.0	S	6	Southerly swell. Hazy.
	Noon	29.748	84.0	S by W	5	Lat. 42° 34' N., Long. 52° 44' E. Distance 235 miles. Fresh breeze and fine.
	4 P.M.	29.698	88.0	SW	5	Hazy.
	8 P.M.	29.748	...	SW	6	Blowing fresh. Moderate sea.
	Midnight	29.748	...	SW	6	Strong breeze and fine. High sea.

THE 4TH TO 13TH JUNE 1887.

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TABLE XI.—10 A.M., 6th June 1887.

STATION.	Barometer.	Change in twenty- four hours.	Abnormal.	WIND.		Ther- mo- meter.	Rela- tive humid- ity.	Cloud.	Rain- fall.	Remarks on the weather at 10 A.M.	
				Direction.	VELOCITY						
					At 10 A.M.	Mean of day.					
	"	"	"		Miles per hour.	Miles per hour.	°	Per cent.	0 to 10	"	
Aden . . .	29.729	—0.29	...	S	...	3	91.1	63	2	Nil.	
Bushire . . .	.488	—0.54	...	SW	...	...	90.8	74	?	Nil.	
Kurrachee . . .	.534	—0.81	—119	WSW	30	23	87.0	70	7	Nil.	Fine weather with passing clouds.
Bhuj . . .	.551	—0.84	—108	SW	16	13	93.2	43	0	Nil.	Blue sky.
Rajkot . . .	.558	—0.84	—131	SW	7	6	92.8	47	2	Nil.	Cloudy.
Surat . . .	.592	—0.94	—153	NW	L*	...	92.5	53	5	Nil.	Fine weather with passing clouds.
Bombay . . .	.621	—0.74	—167	E	4	7	82.5	79	10	4.72	Overcast.
Ratnagiri . . .	.632	—0.73	—174	WSW	10	12	77.8	92	10	2.30	Ditto with rain.
Karwar . . .	.749	—0.31	—086	SW	S*	...	75.1	89	10	3.68	Heavy rain.
Mangalore . . .	.806	—0.43	—040	SSW	8	6	81.4	85	10	0.68	Overcast.
Calicut . . .	.861	—0.52	—022	Calm	...	7	76.6	91	8	2.53	Drizzling rain.
Cochin . . .	.893	—0.53	—014	SE	L*	...	76.0	93	10	1.31	Raining.
Colombo . . .	.903	—0.14	...	WSW	...	14	77.5	71	10	0.23	Overcast.
Galle . . .	.892	—0.29	...	...	...	...	...	...	...	Nil.	
Jacobabad . . .	.393	—0.95	—164	NNW	3	6	101.8	21	0	Nil.	Blue sky.
Hyderabad (Sind)	.478	—1.29	—108	SW	25	21	92.2	48	0	Nil.	Ditto.
Neemuch . . .	.526	—0.92	—118	SW	...	...	96.6	46	0	Nil.	Ditto.
Deesa . . .	.563	—0.83	—112	W	11	11	92.7	43	0	Nil.	Ditto.
Indore . . .	.526	—0.64	—150	W	2	4	92.9	35	1	Nil.	Cloudy.
Akola . . .	.609	—0.53	—086	W	7	7	91.3	45	7	Nil.	Ditto.
Maiegaon . . .	.599	—0.54	—105	E	4	5	86.1	53	10	1.18	Overcast.
Poona . . .	.633	—0.56	—137	W	10	8	79.2	74	10	1.46	Ditto.
Sholapur . . .	.679	—0.68	—090	SSE	11	10	81.6	59	10	Nil.	Ditto.
Belgaum . . .	.711	—0.46	—113	SSW	32	30	70.3	90	10	1.07	Raining.
Bellary . . .	.702	—0.78	—086	SW	...	14	88.3	62	9	0.10	Overcast.
Bangalore . . .	.826	—0.40	—002	SW	...	9	74.2	80	9	Nil.	Dust haze.
Salem . . .	.840	—0.21	—012	SW	...	3	81.5	73	...	Nil.	Fine.

* For abbreviations see foot-note in page 419.

TABLE XII.—6th June 1887.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	WIND		REMARKS.
				Direction.	Force.	
S. S. Akbar.	4 A.M.	...	...	WSW	...	Moderate wind and sea.
	8 A.M.	...	...	W	...	Ditto ditto.
	Noon	29.758	...	...	...	Ditto ditto. Lat. 16° 34' N, Long. 62° 47' E. Course N 78° E. Distance 264 miles.

THE ARABIAN SEA CYCLONE OF

TABLE XII.—6th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
S. S. Akbar—contd.	8 P.M.	...	...	W	...	Moderate wind and sea.
	Midnight	...	...	...	...	Fresh breeze and clear.
S. S. Albani	11-40 A.M.	...	...	S	...	Near Aden. Fresh breeze and overcast.
	8 P.M.	...	...	W	...	Light airs and hazy during the night.
S. S. Chanda	2 A.M.	...	...	NW	...	
	4 A.M.	29.773	86.0	...	...	
	8 A.M.	29.793	84.9	...	...	At Narrakef.
	2 P.M.	...	...	Variable	...	
	4 P.M.	...	...	...	...	Light wind and overcast.
	8 P.M.	29.763	82.0	...	...	Light wind and squally rainy weather.
	11 P.M.	...	...	...	...	Very heavy squall of wind and rain.
S. S. Clan Forbes.	1 A.M.	...	...	SSW	...	Strong wind. High SW sea. Ship labouring and rolling heavily and shipping much water.
	4 A.M.	29.682	85.5	SSW	...	Ditto ditto.
	8 A.M.	29.642	87.5	SSW	...	Strong wind and clear weather. Heavy SW sea. Shipping much water over all. Sea getting more regular.
	Noon	29.602	87.5	SSW	...	Ditto ditto.
	1 P.M.	...	...	WSW	...	Lat. 15° 1' N, Long. 54° 36' E. Course N 76° E. Distance 245 miles.
	4 P.M.	29.632	83.5	WSW	...	Strong wind. Passing clouds. Heavy south-westerly swell. Ship rolling and shipping much water.
	7 P.M.	...	...	SW	...	Ditto ditto.
	8 P.M.	29.592	83.5	SW	...	Wind and sea as above. Weather very clear.
	Midnight	29.592	82.5	SW	...	Ditto ditto.
S. S. Colaba	4 A.M.	29.735	78.8	W	...	Moderate breeze and overcast with heavy swell. Shipping quantities of water.
	8 A.M.	29.736	81.8	W	...	Moderate breeze and cloudy. Frequent squalls. Considerable swell from westward.
	12 A.M.	...	...	W	...	Same wind and weather, but swell moderate.
	Noon	29.753	82.8	...	...	Lat. 13° 50' N, Long. 73° 55' E. Course N 26° W. Distance 142 miles.
	3 P.M.	...	...	...	...	Heavy squall of wind and rain.
	4 P.M.	29.627	78.8	WSW	...	Strong breeze with frequent squalls. Ship rolling heavily and shipping quantities of water.
	8 P.M.	29.642	80.8	WSW	...	Moderate breeze and cloudy. Frequent heavy squalls and high sea. Shipping great quantities of water.
	Midnight	29.624	79.8	WSW	...	Moderate breeze and cloudy. Occasional light squalls. Heavy swell. Ship rolling heavily and shipping water frequently.
S. S. Cuba	1 A.M.	...	...	SW	...	Light breeze and clear weather. Ship rolling heavily.
	4 A.M.	29.565	90.6	...	...	Ditto ditto.
	8 A.M.	29.615	84.6	...	...	
	Noon	29.565	86.6	...	...	Light breeze and heavy beam sea from SW. Lat. 25° 26' N, Long. 68° 40' E. Course S 27° E. Distance 211 miles.
	2 P.M.	...	...	SW	...	Light breeze and fine.
	4 P.M.	29.515	86.6	SW	...	Ditto.

TABLE XII.—6th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Cuba</i> —contd.	8 P.M.	29'515	90'6	SW	...	At 7 P.M. weather same and overcast.
	Midnight	29'515	87'6	SW	...	Light breeze with rain.
<i>S. S. Darien</i>	4 A.M.	...	...	Variable	...	Light variable airs.
	7 A.M.	...	...	Calm	...	
	8 A.M.	29'685	...	...	...	
	Noon	...	90'0	..	...	Lat. 12° 55' N, Long. 46° 0' E. Distance 260 miles.
	8 P.M.	29'685	...	...	...	
	Midnight	...	90'0	Calm	...	
<i>S. S. Deekan</i>	4 A.M.	...	...	W	2	
	4 A.M.	29'776	80'5	...	...	Light monsoon and overcast with rain. West-erly swell. Ship pitching.
	5 A.M.	...	...	...	...	Squally weather with heavy rain.
	8 A.M.	29'806	80'5	NW	...	Light breeze and rainy weather.
	Noon	29'771	82'5	...	...	Lat. 12° 18' N, Long. 74° 46' E. Course N 29° W. Distance 271 miles. Moderate breeze and fine weather.
	1 P.M.	...	...	NW	5 to 6	
	4 P.M.	29'726	80'5	...	...	Strong monsoon and overcast squally weather with heavy rain. West-erly swell. Ship pitching.
	8 P.M.	29'789	79'5	...	...	Strong monsoon and overcast.
<i>S. S. Draco</i>	Midnight	29'784	81'5	...	5 to 6	Fresh monsoon and overcast with frequent squalls of wind and rain.
	1 A.M.	...	...	W	...	Moderate breeze and cloudy. West-erly swell.
	Noon	29'718	...	...	...	Lat. 17° 12' N, Long. 64° 55' E. Course N 77° E. Distance 200 miles. Moderate breeze and fine weather.
	4 P.M.	...	...	NW	...	Moderate breeze and cloudy up to midnight.
<i>S. S. Giata</i>	1 A.M.	29'800	80'6	SSW	6	
	5 A.M.	29'700	82'4	S	6	
	9 A.M.	29'800	84'2	S	6	
	Noon	...	...	...	...	Lat. 14° 25' N, Long. 55° 19' E. Course N 78° E. Distance 256 miles.
	1 P.M.	29'700	82'4	SSW	6	
	5 A.M.	29'600	80'6	SSW	6	
<i>S. S. Henry Balchow</i>	9 P.M.	29'500	78'8	SW	8	Strong wind. Rain squalls. High sea from SW.
	1 P.M.	...	...	E	...	
	4 A.M.	29'523	87'5	...	...	Weather thick and foggy. Sea smooth.
	8 A.M.	29'543	88'5	...	...	Ditto ditto.
	Noon	29'563	91'5	SE	...	Moderate breeze. Near lask. Eight breeze and hazy with rising swell from SE.
	4 P.M.	...	...	S	...	
	4 P.M.	29'543	92'5	...	...	
	6 P.M.	...	...	...	...	Moderate breeze and fine.
	8 P.M.	29'463	92'5	...	...	Fine weather. Hazy horizon.
	9 P.M.	...	...	...	...	Moderate breeze. Smooth sea.

THE ARABIAN SEA CYCLONE OF

TABLE XII.—6th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	WIND		REMARKS.
				Direction.	Force.	
<i>S. S. Henry Bolckow</i> —contd. <i>S. S. Java</i>	Midnight	29.503	88.5	...	...	Light breeze and hazy with smooth sea.
	1 A.M.	...	...	Calm	...	Light airs and fine clear weather.
	4 A.M.	29.507	88.1	...	...	Ditto ditto.
	8 A.M.	29.527	88.1	Calm	...	Light airs and calm.
	Noon	...	...	Calm	...	At Jask, light airs and calm with cloudy weather.
	4 P.M.	29.537	92.1	Calm	...	Hazy weather.
	8 P.M.	29.487	92.9	Calm	...	Ditto.
	Midnight	29.477	90.1	Calm	...	Ditto.
	1 A.M.	...	...	SW	3	Moderate breeze and fine.
<i>S. S. Kangra</i>	4 A.M.	29.563	89.8	SW	3	Light breeze and fine.
	8 A.M.	29.566	88.8	SW	2	Ditto ditto.
	Noon	29.563	89.8	SW	2	Ditto ditto.
	4 P.M.	29.466	92.8	SW	2	Lat. 22° 54' N, Long. 63° 36' E. Course N 50° E. Distance 220 miles.
	8 P.M.	29.451	90.8	SW	3	Light breeze and fine.
	Midnight	29.476	88.8	SW	2	Moderate breeze and fine.
	4 A.M.	...	...	E by S	2	Light breeze and fine weather with passing clouds.
	6 A.M.	...	...	SSE to SW.	4	Thick rainy squally weather; moderate SW swell.
<i>S. S. Kohinur</i>	8 A.M.	...	...	SSE to SW.	4	Moderate wind and cloudy weather.
	Noon	...	...	SSE to SW.	2 to 3	Lat. 30° 31' N, Long. 75° 56' E. Light breeze and clear.
	1 P.M.	...	...	W	2	Fine weather. Cloudy; sea smooth.
	Noon	29.680	...	WSW	...	Lat. 42° 49' N, Long. 63° 17' E. Course N 23° E. Fresh to strong gales with heavy sea. Shipping large quantities of water on deck.
	1 A.M.	...	...	WSW	2	Moderate swell.
<i>S. S. Lorna Doone</i>	2 P.M.	...	...	SW	4	Sea rough. Near Colombo.
	Midnight	29.849	85.5	SW	4	Moderate breeze and cloudy weather.
	4 A.M.	...	...	SW	...	Strong wind and heavy sea. Shipping water fore and aft and ship rolling heavily.
<i>S. S. Oswald</i>	4 A.M.	29.746	84.1	...	...	
	5 A.M.	...	...	SSW	...	
	8 A.M.	29.720	86.9	...	...	
	Noon	...	...	SW	...	Lat. 14° 26' N, Long. 54° 37' E. Course N 77° E. Distance 229 miles. Strong wind and high sea.
	4 P.M.	29.678	87.1	SW	...	
	6 P.M.	29.638	87.1	...	...	
	Midnight	29.666	84.1	...	...	Strong wind and high sea. Ship rolling heavily and shipping water.
	4 A.M.	...	...	WSW	...	Moderate breeze and hazy weather.
<i>S. S. Panama</i>	Noon	...	...	WSW	...	Ditto ditto.
	8 P.M.	...	...	WSW	...	Lat. 36° 34' N, Long. 63° 37' E. Course E by N 1 N. Distance 214 miles.
						Strong breeze and cloudy up to midnight.

TABLE XH.—6th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND		REMARKS.
				Direction.	Force.	
<i>S. S. Pemba.</i>	1 A.M.	"	...	SW by W	...	Moderate breeze and fine clear weather with heavy south-westerly swell. Vessel rolling heavily at times.
	4 A.M.	29.558	86.0	SW by W	...	
	7 A.M.	"	"	SW by W	...	Moderate breeze and swell. Weather fine and clear.
	8 A.M.	29.581	86.0	SW by W	...	Ditto ditto.
	Noon	29.571	86.0	SW by W	...	Ditto ditto.
	1 P.M.	"	...	WSW	...	Lat. 21° 42' N, Long. 69° 20' E. Course S 36° E. Distance 234 miles.
	4 P.M.	29.521	86.0	WSW	...	Moderate breeze and swell; fine weather.
	8 P.M.	29.491	90.0	W	...	
	10 A.M.	"	"	W	...	Gentle breeze and fine but cloudy. Horizon hazy.
	11 P.M.	"	"	SSW	...	Wind sprang up suddenly from SSW. Fresh head breeze and moderate swell. Weather cloudy with thunder, lightning and sharp rain squalls.
	Midnight	29.591	85.0	SSW	...	Ditto ditto.
						Ditto ditto.
<i>S. S. Rockliff.</i>	1 A.M.	"	"	SW	...	Light breeze and clear with strong beam sea.
	8 A.M.	"	"	S	...	
	Noon	"	"	S	...	Lat. 14° 30' N, Long. 51° 45' E. Course N 74° E. Distance 205 miles.
	1 P.M.	"	"	S	...	Light breeze and hazy. Heavy beam sea. Ship rolling heavily and shipping water.
	3 P.M.	"	"	SSW	...	Wind direction SSW up to midnight.
<i>S. S. Rothsay.</i>	1 A.M.	"	"	E	...	
	3 A.M.	"	"	S	...	
	4 A.M.	"	"	S	...	Wind freshening from south.
	8 A.M.	"	"	S	...	Steady breeze and fine.
	9 A.M.	"	"	SW	...	
	Noon	"	97.3	SW	...	Lat. 12° 30' N, Long. 49° 20' E. Course N 88° E. Distance 229 miles. Wind increasing.
	1 P.M.	"	"	SW by W	...	
	6 P.M.	"	"	SW by W	...	Moderate breeze and clear.
<i>S. S. Satara.</i>	Midnight	"	"	SW by W	...	Light breeze and fine with smooth sea.
	4 A.M.	29.632	83.3	"	...	Light breeze and overcast.
	8 A.M.	29.577	85.3	"	...	Moderate breeze and overcast. At Bombay.
	4 P.M.	29.537	85.3	W by N	...	Moderate freshening breeze and cloudy weather with heavy westerly swell.
	8 P.M.	"	"	W by N	...	Squally weather with heavy rain.
	9 P.M.	29.586	85.3	NW	...	
	11 P.M.	"	"	N	...	
	Midnight	29.585	82.3	N	...	Fresh breeze and high sea. Continuous rain.
<i>S. S. Victoria.</i>	4 A.M.	"	"	WNW	...	Overcast sky with passing clouds and occasional showers of rain. Swell from WSW.
	Noon	"	"	WNW	...	Lat. 18° 27' N, Long. 68° 52' E. Course S 83° W. Distance 226 miles. Moderate to fresh breeze and clear, with a long swell from WSW.

THE ARABIAN SEA CYCLONE OF

TABLE XII.—6th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	WIND		REMARKS.
				Direction.	Force.	
<i>S. S. Victoria</i> —contd.	Midnight	...	...	WNW	...	Moderate breeze and clear weather with a SW swell.
<i>S. S. Britannia</i>	1 A.M.	...	...	SW&W	3	Moderate breeze and fair. Slight head sea.
	4 A.M.	29.818	77.4	SW&W	3	Ditto ditto.
	8 A.M.	29.848	80.4	SW&W	3.	Ditto ditto.
	11 A.M.	...	...	SW & W	3	Smart steady breeze.
	Noon	29.858	80.4	SW & W	3	Lat. 6° 44' N, Long. 63° 55' E. Course S 86° W. Distance 18.5 miles. Fair weather. Head sea.
	4 P.M.	29.788	79.4	SW & W	3	Smart breeze and squally.
	8 P.M.	29.798	75.4	SW & W	3	Fresh breeze and squally.
	Midnight	29.798	76.4	SW & W	3	Fresh steady breeze and fine. Head sea. Shipping water.
<i>S. S. Clan Graham</i>	1 A.M.	...	...	Variable	...	
	4 A.M.	29.602	89.8	Variable	...	At 2 A.M. moderate unsteady wind and overcast weather. Ship pitching to head swell and shipping water at times.
	6 A.M.	...	...	NW	...	
	8 A.M.	29.637	87.8	NW	...	Moderate unsteady wind. Dull cloudy weather. High head swell. Vessel plunging heavily and shipping water.
	11 A.M.	...	...	NW	...	Moderate breeze and clear.
	Noon	29.642	89.8	NW	...	Lat. 18° 38' N, Long. 69° 18' E. Course S 86° W. Distance 199 miles. Shipping heavy water at intervals.
	4 P.M.	29.599	90.8	NW	...	Moderate wind. Ship pitching deeply and shipping water over the bows.
	7 P.M.	...	...	WNW	...	Fresh wind and cloudy.
	8 P.M.	29.592	89.8	WNW	...	SW swell. Vessel plunging heavily and shipping much water.
	10 P.M.	...	...	W	...	
	Midnight	29.602	89.8	W	...	Fresh breeze and clear. Shipping water forward.
<i>S. S. Sumatra</i>	8 P.M.	29.579	82.7	W	...	Near Bombay. Light wind and rain. Heavy westerly swell.
	Midnight	...	...	...	...	Fresh breeze. Heavy rain. South-westerly swell.
<i>S. S. Hydaspes</i>	1 A.M.	...	...	W	3 to 4	
	4 A.M.	29.819	77.9	W	3 to 4	Moderate wind and overcast. Frequent squalls of wind and rain.
	8 A.M.	29.804	79.9	W	3 to 4	Moderate monsoon and overcast; fine weather.
	Noon	29.828	81.9	W	3 to 4	Moderate to fresh wind and cloudy. Ship pitching at times to head sea.
	4 P.M.	...	...	WSW	4	Lat. 8° 16' N, Long. 72° 47' E. Course N 76° 42' W. Distance 25.7 miles.
	4 P.M.	29.764	79.9	WSW	4	Moderate wind and passing clouds. Pitching to head sea.
	8 P.M.	29.828	81.9	WSW	4	Moderate wind and cloudy and squally with rain. Ship pitching to head sea.
	Midnight	29.811	80.9	WSW	4	Moderate wind and squally weather. Ship pitching to head sea.
<i>S. S. Assyria</i>	4 A.M.	29.435	84.5	...	...	At Muscat.
	8 A.M.	29.435	87.5	...	...	Light airs and calms.
	Noon	29.425	91.5	...	...	Ditto ditto.
	4 P.M.	29.425	90.5	...	...	Ditto ditto.
	8 P.M.	29.425	89.5	...	...	Ditto ditto.

TABLE XII.—6th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Assyria</i> —contd.	9 P.M.	...	...	W	...	
	Midnight	29.435	89.5	W	...	Light breeze and fine weather.
<i>S. S. Bancoora</i>	4 A.M.	29.764	80.0	W	5 to 7	Squally. Overcast. Continuous rain. Very heavy SW sea.
	8 A.M.	29.784	80.0	WNW	5	Violent squalls and dirty appearance. Very heavy SW sea.
	Noon	29.784	80.0	WNW	6	Lat. 16° 13' N, Long. 73° 12' E. Violent squalls. Heavy rain. Very heavy SW sea.
	4 P.M.	29.652	81.0	W	4	Violent squalls. Continuous heavy rain. Very heavy SW sea.
	8 P.M.	29.649	82.0	W	4	Ditto ditto.
	Midnight	29.645	80.0	W	4	Violent squalls. Overcast, thick and rainy weather. Very heavy SW sea.
<i>S. S. Clan Matheson</i>	4 A.M.	29.697	87.0	Calm	1	Calms and light and variable airs.
	8 A.M.	29.760	86.0	Calm	1	Ditto ditto.
	Noon	29.703	85.0	Calm	2	Lat. 12° 55' N, Long. 51° 13' E. Light breeze and clear. Heavy southerly swell.
	4 P.M.	29.658	83.0	SE	4	Moderate and increasing wind and clear weather.
	8 P.M.	29.671	82.0	S by W	5	Fresh wind and rising sea.
	Midnight	29.651	82.0	SSW	7	Strong monsoon. High sea. Ship rolling heavily and shipping water.
<i>S. S. Fumna</i>	4 A.M.	29.842	75.0	W by S	5	Fresh wind with high confused sea.
	8 A.M.	29.818	80.0	W by S	5	Wind and sea increasing.
	Noon	29.818	80.0	W by S	6	Lat. 8° 41' N, Long. 66° 25' E. Distance 240 miles. Strong wind and cloudy.
	4 P.M.	29.808	80.0	SW	5	Strong wind and high sea.
	8 P.M.	29.834	74.0	WSW	6	Strong monsoon with high sea.
	Midnight	29.817	73.0	WSW	6	Strong monsoon with hard squalls and torrents of rain.
<i>S. S. Kerbela</i>	1 A.M.	...	...	W	4	
	3 A.M.	...	...	W	4	Brisk breeze and fine clear weather.
	4 A.M.	29.571	84.9	W	4	
	8 A.M.	29.611	86.9	W	4	Moderate breeze and fine clear weather.
	Noon	29.591	86.9	W	4	Ditto ditto.
	1 P.M.	...	...	WNW	4	Lat. 22° 38' N, Long. 67° 58' E. Course N 50° W. Distance 207 miles.
	4 P.M.	29.491	86.9	WNW	4	
	8 P.M.	29.511	88.9	WNW	4	Fresh breeze and fine weather.
	Midnight	29.571	86.9	WNW	4	Moderate breeze with passing clouds. Swell from WSW.
<i>S. S. Manora</i>	4 A.M.	29.652	80.0	S by W	7	Strong breeze and clear.
	8 A.M.	29.664	83.0	S by W	3	Light wind. Heavy southerly swell.
	Noon	29.634	88.0	W	4	Lat. 13° 19' N, Long. 50° 51' E. Distance 262 miles.
	...	...	...	...	...	Fresh breeze and fine.
	4 P.M.	29.642	85.0	W	3	Moderate breeze and fine.
	8 P.M.	29.657	86.0	W	2	Light breeze; fine and clear.
	Midnight	29.619	85.0	W	2	Light wind and fine.

THE ARABIAN SEA CYCLONE OF

TABLE XII.—6th June 1887—concluded.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Mecca</i>	4 A.M.	29'704	...	...	...	Wind and sea increasing.
	8 A.M.	29'724	...	...	...	Strong breeze with a high breaking sea.
	Noon	29'854	...	...	...	Lat. 4° 52' N. Long. 52° 17' E. Distance 158 miles. Wind decreasing.
	4 P.M.	29'714	...	...	...	
	8 P.M.	29'754	...	...	...	
	9-30 P.M.	...	...	...	...	Weather moderating considerably.
	Midnight	29'854	...	...	...	Moderate breeze and sea. Squally at times.
<i>S. S. Navarino</i>	4 A.M.	29'708	90°0	SW	6	Strong gale with very hard squalls.
	8 A.M.	29'748	88°0	SW	7	
	Noon	29'748	89°0	SW	7	Lat. 12° 41' N. Long. 56° 59' E. Distance 274 miles. Strong monsoon and high sea.
	4 P.M.	29'678	90°0	SW	7	Strong monsoon and high sea.
	8 P.M.	29'728	88°0	SW	7	Ditto ditto.
	Midnight	29'688	88°0	SW	7	Ditto ditto.

TABLE XIII.—10 A.M., 7th June 1887.

STATION.	Barometer.	Change in 24 hours.	Abnormal.	WIND.			Ther- mome- ter.	Rela- tive humid- ity.	Cloud.	Rain- fall.	Remarks on the weather at 10 A.M.
				Direction.	VELOCITY.						
					At 10 A. M.	Mean of day.					
	"	"	"		Miles per hour.	Miles per hour.	°	Per cent.	0 to 10.	"	
Aden	29'669	—'060	...	S	...	4	50'7	68	1	Nil.	
Bushire	'470	—'018	...	NW	...	...	91'8	62	?	Nil.	
Kurrachee	'489	—'045	—'160	WSW	23	23	90'0	61	3	Nil.	Fine weather with passing clouds.
Bhuj	'508	—'043	—'148	SW	10	14	92'0	49	4	Nil.	Cloudy.
Rajkot	'526	—'032	—'160	WNW	5	4	87'5	64	6	Nil.	Ditto.
Surat	'561	—'031	—'181	NNW	L*	...	86'1	66	9	0'39	Dark gloomy weather.
Bombay	'553	—'068	—'233	ESE	12	11	78'4	91	10	2'40	Overcast with rain.
Ratnagiri	'595	—'037	—'209	S	20	13	80'3	82	10	2'15	Overcast.
Karwar	'677	—'072	—'157	SW	F*	...	81'6	80	9	0'69	Drizzling rain.
Mangalore	'768	—'018	—'086	SSW	6	5	78'9	80	10	2'76	Raining.
Calicut	'833	—'028	—'051	S	5	7	74'6	79	10	6'18	Dark gloomy weather.
Cochin	'877	—'016	—'018	W	L*	...	73'9	93	10	2'47	Overcast with rain.
Colombo	'864	—'039	...	S	...	11	80'5	72	10	0'25	Overcast.
Galle	'852	—'040	...	NW	6	8	79'0	95	8	1'21	

* For abbreviations see foot-note in page 419.

TABLE XIII.—10 A.M., 7th June 1887—concluded.

STATION.	Barometer	Change in 24 hours.	Abnormal.	WIND.				Ther- mo- meter.	Rela- tive, humid- ity.	Clos.	Rain- fall.	Remarks on the weather at 10 A.M.
				Direction.	VELOCITY.		°					
					At 10 A.M.	Mean of day.						
	"	"	"		Miles, per hour.	Miles per hour.		Per cent.	0 to 10.	"		
Jacobabad	29'453	+ '060	— '099	SE	9	3	100'6	31	0	Nil.	Dust haze.	
Hyderabad (Sind)	'463	— '015	— '119	SSW	15	18	92'8	49	0	Nil.	Blue sky.	
Neemuch	'501	— '025	— '141	W	...	...	94'7	51	0	Nil.	Ditto.	
Deesa	'537	— '026	— '135	WSW	4	9	91'6	47	6	Nil.	Cloudy.	
Indore	'499	— '027	— '174	SSW	8	4	94'4	29	2	Nil.	Ditto.	
Akola	'575	— '034	— '118	SSE	11	7	91'4	45	5	Nil.	Ditto.	
Malegaon	'571	— '028	— '132	SE	9	5	81'7	69	10	0'08	Overcast.	
Poona	'595	— '038	— '174	ESE	7	5	76'6	81	10	0'31	Ditto.	
Sholapur	'614	— '056	— '145	SSW	13	10	82'4	57	9	Nil.	Cloudy.	
Belgaum	'628	— '083	— '196	SSW	28	28	73'3	84	10	0'83		
Pellary	'692	— '010	— '096	SW	...	14	81'9	65	10	Nil.	Overcast.	
Bangalore	'812	— '014	— '017	SW	...	8	70'7	88	10	0'11	Ditto.	
Salem	'822	— '018	— '029	W	...	2	83'5	69	6	Nil.	Very fine.	

TABLE XIV.—7th June 1887.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	WIND.		REMARKS.
				Direction.	Force.	
S. S. Akbar	1 A.M.	...	...	W	...	
	4 A.M.	...	...	...	...	Moderate breeze and overcast.
	Noon	29'618	...	...	...	Ditto ditto. Lat. 17° 39' N, Long. 67° 7' E. Course N 76° E. Distance 257 miles.
	1 P.M.	...	...	W	...	
	4 P.M.	...	...	...	...	Fresh breeze with passing showers.
	8 P.M.	...	...	WNW	...	Strong breeze and squally appearance.
	Midnight	...	...	...	...	Heavy rain squalls.
S. S. Albany	Noon	...	...	SW	...	Lat. 13° 32' N, Long. 49° 6' E. Course N 78° 29' E. Distance 240 miles. Moderate wind and hazy.
S. S. Assam	7 P.M.	...	...	SSE	...	Near Bombay.
	8 P.M.	29'465	82'7	...	...	Moderate monsoon and overcast.
	10 P.M.	...	...	...	5	Drizzling rain. Squally at times.
	Midnight	29'466	84'7	...	4	Fresh to moderate wind. Ship pitching heavily to SW sea and shipping water forward.
S. S. Chanda	4 A.M.	...	...	...	...	Light wind. Cloudy and overcast.
	8 A.M.	29'743	80'0	...	...	
	9 A.M.	...	...	...	...	Heavy squall of wind and rain.

THE ARABIAN SEA CYCLONE OF

TABLE XIV.—7th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Chanda</i> —contd.	Noon	...	...	...	...	At Narrakel. Rain throughout the forenoon.
	2 P.M.	...	...	SW	...	
	4 P.M.	29.723	80.0	SW	...	Light breeze and rainy weather.
	8 P.M.	29.733	82.0	SW	...	Ditto ditto.
	10 P.M.	...	...	SSW	...	Sky dark and overcast. Lightning to N and NW.
	Midnight	29.723	82.0	SSW	...	Light breeze and drizzling rain. Sky overcast with flashes of lightning to NW.
<i>S. S. Clan Forbes</i>	2 A.M.	...	...	SW	...	Strong wind and clear weather with high SW sea. Ship rolling badly and shipping much water.
	4 A.M.	29.582	79.5	SW	...	Ditto ditto.
	8 A.M.	29.612	83.5	SW	...	Strong wind. High following sea. Shipping water fore and aft. Occasional passing clouds with light drizzle.
	Noon	29.622	89.5	SW	...	Lat. 15° 42' N, Long. 58° 33' E. Course N 80° E. Distance 202 miles. Strong wind. High following sea. Shipping water fore and aft. Occasional passing clouds with light drizzle. Very heavy sea.
	4 P.M.	...	...	SW	...	Strong wind. High following sea. Decks flooded fore and aft.
	4 P.M.	29.582	85.5	SW	...	Ditto ditto.
	8 P.M.	29.562	86.5	SW	...	Strong wind. Hazy. Overcast. High following sea. Decks flooded.
	Midnight	29.562	85.5	SW	...	Strong wind. High following sea. Clear.
	2 A.M.	...	...	...	...	Moderate breeze and fine.
	4 A.M.	29.572	76.8	WSW	...	Light breeze and overcast with rain.
<i>S. S. Gelaba</i>	6 A.M.	...	...	Variable	...	Light wind and continuous rain.
	8 A.M.	29.627	78.8	W	...	Moderate breeze and squally. Continuous heavy rain.
	Noon	29.527	78.8	SSW	...	Lat. 16° 6' N, Long. 73° 1' E. Course various. Distance 142 miles.
	4 P.M.	29.484	79.8	WSW	...	Moderate breeze with passing clouds and occasional squalls.
	6 P.M.	...	...	...	...	Frequent rain squalls.
	8 P.M.	29.504	79.8	SW	...	Moderate breeze and cloudy.
	Midnight	29.504	79.8	S	...	At 11 P.M. moderate breeze and cloudy. Occasional rain squalls.
	2 A.M.	...	...	SW	...	Light breeze and squally with heavy rain at times.
	4 A.M.	29.525	83.6	WNW	...	Light breeze with thunder and lightning. Heavy rain at times.
	8 A.M.	29.515	84.6	NW	...	At 6 A.M. wind NW.
<i>S. S. Cuba</i>	9 A.M.	...	...	NE	...	
	Noon	29.535	82.6	NE	...	Lat. 19° 32' N, Long. 71° 46' E. Course S 57° E. Distance 250 miles. Fresh breeze with heavy rain at times.
	1 P.M.	...	...	NNE	...	Fresh breeze and squally with heavy rain at times.
	4 P.M.	29.515	84.6	E	...	Ditto ditto.
	8 P.M.	29.505	82.6	...	...	
	1 A.M.	...	...	SW	...	Light wind and cloudy weather.
	8 A.M.	29.585	...	...	...	
<i>S. S. Darien</i>	1 A.M.	...	...	SW	...	Light wind and cloudy weather.
	8 A.M.	29.585	...	...	...	

TABLE XIV.—7th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Darion</i> —contd.	Noon	...	88°0	SSW	...	Lat. 13° 9' N, Long. 50° 10' E. Course E by N½ N. Distance 246 miles.
	4 P.M.	...	...	SSW	...	
	8 P.M.	29°58½	...	...	...	Wind increasing.
	Midnight	...	88°0	SSW	...	Steady SSW wind.
<i>S. S. Deckaw</i>	1 A.M.	...	...	W	2 to 3	
	4 A.M.	29°709	79°5	W	2 to 5	Light monsoon and overcast squally weather. Ship rolling to westerly swell.
	6-30 A.M.	...	...	W	4	Squally with heavy rain.
	7 A.M.	...	...	WSW	4	
	8 A.M.	29°664	81°5	WSW	4	
	Noon	...	80°5	...	...	Lat. 16° 19' N, Long. 73° 12' E. Course N 18½° W. Distance 290 miles. Light breeze and overcast with continuous small rain.
	1 P.M.	...	...	SW	2 to 4	
	4 P.M.	29°504	81°5	...	...	Light monsoon and overcast squally weather with rain. South-westerly swell.
	8 P.M.	29°582	82°5	...	3	Light wind and overcast with passing squalls.
	Midnight	29°604	81°5	...	...	Light following breeze and cloudy with occasional rain squalls.
<i>S. S. Draco</i>	1 A.M.	...	...	WNW	...	Moderate breeze and cloudy.
	8 A.M.	...	...	WNW	...	Ditto ditto with passing showers of rain.
	Noon	29°608	...	WNW	...	Lat. 18° 1' N, Long. 68° 15' E. Course N 76° E. Distance 200 miles. Strong squall of wind and rain.
	4 P.M.	...	...	WNW	...	Fresh breeze and constant heavy rain.
	4 P.M.	...	...	WNW	...	Ditto ditto. Dark gloomy appearance.
	8 P.M.	...	...	WSW	...	Strong breeze and high confused sea.
	Midnight	...	...	WSW	...	Heavy thunder and lightning and heavy squall of rain.
						Ditto ditto.
<i>S. S. Giava</i>	1 A.M.	29°600	80°6	SW	10	
	5 A.M.	29°700	82°4	SSW	10	
	9 A.M.	29°700	84°2	SSW	10	
	Noon	...	...	...	...	Lat. 25° 31' N, Long. 49° 49' E. Course N 80° E. Distance 258 miles.
	1 P.M.	29°700	84°2	SSW	8	Strong wind and squalls. Gale. Rain and high sea.
	5 P.M.	29°700	82°4	SSW	8	
	9 P.M.	29°600	82°4	SSW	8	
<i>S. S. Henry Bolckow</i>	9 A.M.	...	...	Calm	...	Hazy weather. Sea smooth.
	4 A.M.	29°503	88°5	Calm	...	Ditto ditto.
	7 A.M.	...	...	E	...	
	8 A.M.	29°503	88°5	Calm	...	Hazy with light increasing swell from south.
	Noon	29°513	89°5	Calm	...	Lat. 24° 33' N, Long. 60° 54' E. Course S 70° E. Distance 277 miles.
	1 P.M.	...	...	SSE	...	
	4 P.M.	29°503	86°5	...	...	Moderate breeze with fine clear weather. Light increasing swell from southward.

THE ARABIAN SEA CYCLONE OF

TABLE XIV.—7th June 1857—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Henry Bolckow</i> — contd.	6 P.M.	...	...	S to SSE	...	Hazy weather. Rising sea from southward. Moderate breeze.
	8 P.M.	29'483	86'5	...	...	
	9 P.M.	...	...	ESE	...	
	Midnight	29'493	83'5	...	...	
<i>S. S. Japa</i> . . .	1 A.M.	...	...	Calm	...	Light breeze and fine weather. Ship rolling heavily. Southerly swell.
	4 A.M.	29'497	90'1	Calm	...	
	Noon	...	...	Calm	...	
	4 P.M.	...	...	Calm	...	
	8 P.M.	29'447	92'1	...	...	
	Midnight	29'447	90'1	...	...	
<i>S. S. Kangra</i> . . .	1 A.M.	...	...	SW	2	Hazy weather. At Muscat. Hazy weather. Light airs. Light wind. Fine clear weather. Ditto Ditto.
	4 A.M.	29'473	89'8	SW	2	
	8 A.M.	29'474	85'8	SW	2	
	Noon	29'498	87'8	SW	2	
	4 P.M.	29'531	86'8	...	...	
	8 P.M.	29'536	84'8	...	...	
<i>S. Lorna Doone</i> . . .	Noon	29'660	...	WNW	...	Lat. 15° 54' N. Long. 63° 55' E. Course N 11° E. Fresh to strong gale.
<i>S. S. Nizam</i> . . .	1 A.M.	...	...	NW	2	
	4 A.M.	29'632	82'3	...	3	Moderate wind and fine hazy weather. At Aden. Moderate wind. Course various. Distance 285 miles. Moderate breeze and fine weather. Ditto ditto. Light breeze and fine weather.
	8 A.M.	29'617	84'3	...	4	
	Noon	29'530	91'3	S	...	
	4 P.M.	29'583	90'3	S	...	
	8 P.M.	29'511	87'3	...	...	
	Midnight	29'524	85'3	SE	2	
	1 A.M.	...	...	SW	3	
	2-30 A.M.	...	...	SW	7	
<i>S. S. Nurjahan</i> . . .	3 A.M.	...	...	WSW	5	Moderate SW swell. Squally with heavy rain. Fresh breeze and cloudy. Sea rough.
	4 A.M.	29'827	82'5	WSW	5	
	8 A.M.	29'797	...	WSW	5	
	Noon	29'827	85'5	WSW	4	
	1 P.M.	...	...	WSW	3	
	2 P.M.	...	...	WSW	2	Lat. 8° 31' N. Long. 78° 19' E. Course various. Distance 130 miles. Moderate breeze and cloudy. Fresh breeze and cloudy.
	9 P.M.	...	...	NW	2	
	Midnight	29'767	83'5	NW	2	
	1 A.M.	...	...	WNW	3	
	4 A.M.	...	...	WNW	3	
<i>S. S. Orion</i> . . .	8 A.M.	...	...	WNW	3	Ditto ditto.

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TABLE XIV.—7th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Orion</i> —contd	Noon	...	...	WNW	4	Lat. 18° 0' N. Long. 70° 19' E. Agitated sea. Cumulus clouds.
	1 P.M.	...	...	NW	6	Very agitated sea. Nimbus clouds. Strong squalls of rain at intervals. Horizon dark.
	4 P.M.	29'542	...	NW	6	Ditto ditto.
	4-30 P.M.	29'542	...	NW	6	Ditto ditto.
	5 P.M.	29'522	...	NNW	6	Ditto ditto.
	5-30 P.M.	29'518	...	NNW	6	Ditto ditto.
	6 P.M.	29'518	...	N	7	Ditto ditto.
	6-30 P.M.	29'530	...	N	7	Ditto ditto.
	7 P.M.	29'534	...	NNE	6	Ditto ditto.
	8 P.M.	29'548	...	NNE	6	Ditto ditto.
	9 P.M.	...	...	ENE	6	Ditto ditto.
	10 P.M.	...	...	NE	6	Ditto ditto.
	11 P.M.	...	...	ESE	6	Ditto ditto.
	Midnight	29'568	...	ESE	6	Ditto ditto.
<i>S. S. Ormald</i>	4 A.M.	...	...	SW	...	Strong wind and heavy sea. Ship rolling heavily and shipping water fore and aft.
	5 A.M.	29'663	84'1	SW	...	
	9 A.M.	29'683	85'1	SW	...	At 8 A.M. strong wind and cloudy.
	Noon	...	...	SW	...	Lat. 15° 21' N. Long. 58° 21' E. Course N 76° E. Distance 223 miles. Strong wind and heavy sea and cloudy.
	1 P.M.	29'641	86'1	SW	...	Strong wind and heavy sea.
	5 P.M.	29'604	85'1	SW	...	Ditto ditto.
	Midnight	29'646	84'1	SW	...	Ditto ditto.
<i>S. S. Panama</i>	2 A.M.	...	...	WNW	...	Strong breeze and overcast.
	Noon	...	...	WNW	...	Lat. 17° 20' N. Long. 67° 59' E. Course E by N ½ N. Distance 210 miles. Strong breeze and fine weather.
	1 P.M.	...	...	...	...	Strong gale and squally.
	4 P.M.	...	...	WNW	...	Strong gale with heavy rain squalls.
	Midnight	...	...	WNW	...	Strong gale and high sea.
<i>S. S. Pemba</i>	1 A.M.	...	...	SW	...	Weather clearing a little. Wind lessening. Severe flashes of lightning.
	2 A.M.	...	...	NW	...	Wind hauling to NW, afterwards to NE with rain and sharp lightning.
	4 A.M.	29'491	85'0	NE	...	
	7 A.M.	...	...	ESE	...	
	8 A.M.	29'491	83'0	ESE	...	
	9 A.M.	...	...	SE	...	
	Noon	29'500	83'0	SE	...	At Bombay.
	8 P.M.	29'521	79'0	SE	...	
<i>S. S. Rockliff</i>	1 A.M.	...	...	SSW	...	Strong breeze. Hazy with heavy beam sea. Ship rolling heavily and shipping much water amid ship.

THE ARABIAN SEA CYCLONE OF

TABLE XIV.—7th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Rockliff</i> —contd.	Noon	...	...	SSW	...	Strong breeze. Hazy with heavy beam sea. Ship rolling heavily and shipping much water amid ship. Lat. $15^{\circ} 21' N$, Long. $55^{\circ} 30' E$. Course $N 74^{\circ} E$. Distance 216 miles.
	Midnight	...	...	SSW	...	
<i>S. S. Rothsay</i>	1 A.M.	...	...	SW by W	...	Slight swell from SSW.
	4 A.M.	...	...	SW by W	...	Light airs and clear.
	7 A.M.	...	...	WSW	...	At 8 A.M. light wind and fine weather.
	10 A.M.	...	...	SW	...	
	Noon	29.623	...	SW	...	Lat. $12^{\circ} 52' N$, Long. $50^{\circ} 37' E$. Course $N 85^{\circ} E$. Distance 153 miles. Moderate wind and clear.
	1 P.M.	...	...	SW by W	...	At 8-28 P.M. ship rolling heavily.
	9 P.M.	...	...	SSE	...	
	Midnight	...	...	SSE	...	Fresh breeze and hazy.
<i>S. S. Satara</i>	1 A.M.	...	...	W by N	...	
	4 A.M.	29.570	84.3	W by N	...	Moderate breeze and cloudy. Heavy swell.
	5 A.M.	...	...	WNW	...	
	8 A.M.	29.567	85.3	WNW	...	Moderate breeze. Weather overcast.
	Noon	29.522	87.3	WNW	...	Lat. $21^{\circ} 16' N$, Long. $69^{\circ} 21' E$. Course $N 53^{\circ} W$. Distance 240 miles. Moderate breeze and cloudy. Heavy swell.
	1 P.M.	...	...	NW by W	...	
	4 P.M.	29.513	87.3	NW by W	...	Moderate breeze and cloudy weather.
	8 P.M.	29.525	86.3	NW by W	...	Moderate breeze and fine weather. Heavy swell from SW. Ship rolling heavily.
	10 P.M.	...	...	NW	...	
	Midnight	29.549	85.3	NW	...	Moderate head wind and overcast with westerly swell.
<i>S. S. Victoria</i>	8 A.M.	...	...	W	...	Moderate breeze and clear with a long swell from SW.
	Noon	...	...	W	...	Ditto ditto.
	Midnight	...	...	SW	...	Lat. $17^{\circ} 53' N$, Long. $65^{\circ} 26' E$. Course $S 80^{\circ} W$. Distance 201 miles.
<i>S. S. Britannia</i>	1 A.M.	...	...	SW & W	4	Fresh breeze with a heavy sea. Ship labouring at times and taking water on board fore and aft.
	3 A.M.	...	...	SW & W	4	Fresh breeze and squally.
	4 A.M.	...	78.4	SW & W	4	Dull overcast sky.
	7 A.M.	...	...	SW & W	5	Fresh to strong breeze and fair weather.
	8 A.M.	29.798	76.4	SW & W	5	Head sea. Shipping water.
	Noon	29.788	78.4	SW & W	5	Lat. $6^{\circ} 54' N$, Long. $61^{\circ} 10' E$. Course $N 86^{\circ} W$. Distance 164 miles.
	4 P.M.	29.728	79.4	SW & W	5	Strong breeze and cloudy. Head sea. Shipping much water.
	8 P.M.	29.768	77.4	SW & W	5	Strong breeze and cloudy.
	Midnight	...	76.4	SW & W	5	Ditto ditto.
						Strong breeze and dull overcast sky.

TABLE XIV.—7th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Clan Graham</i>	2 A.M.	...	...	WNW	...	At 2 A.M. moderate to fresh wind and fine weather. Ship pitching heavily to head swell and shipping water forward.
	4 A.M.	29'588	87'8	WNW	...	Ditto ditto.
	8 A.M.	29'605	88'8	WNW	...	Ditto ditto.
	12 A.M.	...	...	WNW	...	Fresh breeze and cloudy.
	Noon	29'622	89'8	WNW	...	Lat. 18° 28' N, Long. 66° 1' E. Course S 89° W. Distance 192 miles. High head sea.
	1 P.M.	...	...	W	...	
	4 P.M.	29'550	90'8	W	→	Fresh head wind and cloudy. Ship rolling and pitching to high swell and shipping heavy water at times.
	8 P.M.	29'555	88'8	W	...	Ditto ditto.
	Midnight	29'558	87'8	W	...	At 12 P.M. shipped several heavy seas forward filling decks.
	1 A.M.	...	...	NW	...	
<i>S. S. Sumatra</i>	4 A.M.	29'545	80'7	NW	...	Light wind with very heavy squalls of rain. Confused sea.
	6 A.M.	...	...	NW	→	Preparing for bad weather.
	8 A.M.	29'545	79'7	NW	...	Fresh breeze and passing heavy squalls of wind and rain. Confused heavy swell.
	2 P.M.	...	...	NW	...	Heavy confused swell from SW and W.
	Noon	29'545	80'7	NW	...	Lat. 18° 17' N, Long. 70° 31' E. Course various. Distance 141 miles. Strong breeze and heavy rain squalls.
	4 P.M.	29'502	81'7	NW	...	Fresh to strong breeze and fine overcast sky.
	6 P.M.	...	...	SW to NW	...	
	8 P.M.	29'516	79'7	SW to NW	...	Fresh breeze with continued heavy rain. Passing hard squalls and very thick weather.
	9 P.M.	...	...	NW	...	
	10 P.M.	29'475	...	NW	...	Continued heavy rain and thick at times.
<i>S. S. Hydaspes</i>	Midnight	29'485	80'7	...	...	Strong breeze and very heavy rain. Big head sea.
	1 A.M.	...	...	SW	4 to 5	
	4 A.M.	29'739	81'9	SW	4 to 5	Fresh monsoon, squally and overcast. Ship pitching to SW sea and taking water over.
	8 A.M.	29'737	78'9	SW	4 to 5	Strong monsoon, squally and overcast. Ship pitching heavily at times and shipping large quantities of water forward.
	10 A.M.	...	...	SW	4 to 5	Strong monsoon and squally.
	Noon	29'684	79'9	SW	4 to 5	Lat. 9° 24' N, Long. 69° 31' E. Course N 75° W. Distance 222 miles. Fresh monsoon and cloudy. Ship pitching and shipping much water.
	1 P.M.	...	...	SW	4	
	4 P.M.	29'697	78'9	SW	4	Fresh monsoon and cloudy. Pitching and shipping water fore and aft.
	8 P.M.	29'687	78'9	SW	4	Fresh monsoon and cloudy. Ship pitching and shipping large quantities of water at times forward.
	Midnight	29'732	80'9	SW	4 to 5	Fresh monsoon and cloudy. Ship pitching and shipping large quantities of water forward.
<i>S. S. Assyria</i>	4 A.M.	29'415	86'5	NW	...	Light breeze and fine weather. Smooth sea.
	8 A.M.	29'435	90'5	NW	→	Light breeze and fine weather.

THE ARABIAN SEA CYCLONE OF

TABLE XIV.—7th June 1887—continued.

NAME OF VESSEL.	HOURS.	Barometer.	Thermo- meter.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Assyria</i> —contd.	Noon	29.465	85.5	NW	...	Light breeze and fine weather.
	1 P.M.	...	...	NNW	...	Lat. 25° 39' N, Long. 57° 30' E.
	4 P.M.	29.375	90.5	NNW	...	Light wind and fine.
	5 P.M.	...	...	W	...	
	8 P.M.	29.375	87.5	W	...	Light breeze and fine.
	Midnight	29.375	86.5	W	...	Fine clear weather.
<i>S. S. Bancoora</i>	4 A.M.	29.345	80.0	Variable	2 to 5	Thick weather and overcast with continuous heavy rain and heavy SW sea.
	Noon	...	...	...	...	At Bombay.
<i>S. S. Clan Matheson</i>	4 A.M.	29.658	83.0	SSW	6	Wind and sea moderating.
	8 A.M.	29.655	84.0	SW	7	Freshening again.
	Noon	29.628	83.0	SW	7	Lat. 13° 28' N, Long. 55° 34' E. Strong monsoon. High sea.
	4 P.M.	29.386	84.0	SW	7	Rolling very heavily and shipping water all over.
	8 P.M.	29.658	83.0	SW	7	Ditto ditto.
	Midnight	29.651	82.0	SW	7	No improvement. Heavy clouds from SW.
<i>S. S. Jumna</i>	4 A.M.	29.778	76.0	WSW	8	Fresh gale. Strong squalls and rain.
	8 A.M.	29.768	80.0	WSW	6	Strong monsoon and cloudy.
	Noon	29.758	80.0	WSW	7	Lat. 8° 39' N, Long. 62° 50' E. Distance 204 miles. Strong monsoon with high sea.
	4 P.M.	29.768	80.0	SW	7	Strong gale and very high sea.
	8 P.M.	29.778	76.0	SW	6	Strong monsoon and cloudy sky.
	Midnight	29.772	75.0	SW	7	Increasing wind and sea.
<i>S. S. Kerbela</i>	1 A.M.	...	...	W	3	
	3 A.M.	...	...	W	3	Moderate breeze and cloudy.
	4 A.M.	29.471	84.9	W	3	
	8 A.M.	29.511	86.9	...	...	
	10 A.M.	...	...	...	...	Moderate breeze and fine with a swell from westward.
	Noon	29.491	88.9	...	...	At Kurrachee.
<i>S. S. Manora</i>	4 A.M.	29.601	88.0	WSW	3	Moderate breeze and fine.
	8 A.M.	29.647	90.0	WSW	5	Fresh breeze and clear.
	Noon	29.647	90.0	WSW	5	Lat. 12° 25' N, Long. 48° 9' E. Distance 282 miles. Fresh breeze and fine.
	4 P.M.	29.500	89.0	W by S	3	Moderate breeze and fine.
	6.50 P.M.	...	...	...	...	Arrived at Aden.
	8 P.M.	29.542	88.0	WSW	3	
	Midnight	29.498	97.0	N	4	
<i>S. S. Mecca</i>	4 A.M.	29.874	...	...	...	Moderate wind and sea and fine clear weather.
	8 A.M.	29.824	...	...	...	Light breeze with squally appearance to the southward. Sea going down.
	Noon	29.854	...	SW	...	Lat. 2° 1' N, Long. 51° 38' E. Distance 175 miles.
	4 P.M.	29.814	...	...	...	Moderate wind and cloudy. SSW swell.
	8 P.M.	29.854	...	...	...	Light breeze and cloudy. Slight confused sea.

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TABLE XIV.—7th June 1887—concluded.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Mecca</i> —contd.	Midnight	29.784	...	SW	...	Moderate breeze. Confused head sea. Cloudy with passing squalls.
<i>S. S. Nasarino</i>	4 A.M.	29.688	88.0	SW	6	Increasing wind and sea.
	8 A.M.	29.738	90.0	SW	6	Strong wind and high sea.
	Noon	29.698	90.0	SW	5	Lat. 11° 56' N, Long. 61° 21' E. Distance 260 miles. Fresh monsoon and cloudy weather.
	4 P.M.	29.658	89.0	SW	5	Fresh breeze and squally.
	8 P.M.	29.718	90.0	SW	5	Moderate gale with squalls and rain.
	Midnight	29.688	90.0	SW	5	Fresh breeze and fine weather.
<i>S. S. Morrow</i>	1 P.M.	...	...	SW	...	At Bombay. Squally and rain.
	5 P.M.	...	...	W	...	
	Midnight	...	...	W	...	Near Bombay. Rain with squalls and high sea.

TABLE XV.—10 A.M., 8th June 1887.

STATION.	Barometer.	Change in 24 hours.	Abnormal.	WIND.			Ther- mome- ter.	Rela- tive humid- ity.	Cloud.	Rain- fall.	Remarks on the weather at 10 A.M.
				Direction.	VELOCITY.						
					At 10 A.M.	Mean of day.					
	"	"	"		Miles per hour.	Miles per hour.	°	Per cent.	0 to 10.	"	
Aden	29.646	—0.023	...	SW	...	12	89.8	75	0	Nil.	
Bushire	.502	+0.032	...	NW	...	...	91.8	61	?	Nil.	
Kurrachee	.499	+0.010	—0.146	W	12	14	93.0	58	2	Nil.	Fine weather with passing clouds.
Bhuj	.515	+0.007	—0.137	ENE	12	8	93.7	45	6	0.01	Cloudy.
Rajkot	.518	—0.008	—0.164	NNE	5	7	91.8	51	8	0.18	Ditto.
Surat	.557	—0.004	—0.182	E	M*	...	90.5	55	6	0.01	Fine weather with passing clouds.
Bombay	.553	0	—0.230	SE	32	...	84.4	73	9	0.01	Ditto ditto.
Ratnagiri	.594	—0.001	—0.209	S	...	...	79.3	98	10	0.88	Overcast.
Karwar	.667	—0.010	—0.166	SW	F*	...	75.6	89	10	2.48	Drizzling rain.
Mangalore	.764	—0.004	—0.090	SSE	2	5	76.4	93	10	2.32	Dark gloomy weather.
Calicut	.832	—0.001	—0.052	Calm	0	9	74.5	90	10	2.07	Ditto ditto.
Cochin	.858	—0.019	—0.050	NNW	L*	...	77.0	93	10	1.32	Ditto ditto.
Colombo	.858	—0.006	...	SSW	...	7	82.0	65	7	0.29	Fine.
Galle	.850	—0.002	...	NW	10	10	79.0	91	5	0.90	
Jacobabad	.502	+0.049	—0.046	SE	14	4	106.4	13	0	Nil.	Dust storm.
Hyderabad (Sind)	.498	+0.035	—0.079	Calm	1	8	104.9	21	4	Nil.	Cloudy.
Neemuch	.590	+0.089	—0.049	S	...	..	87.8	63	6	0.09	Ditto.
Deesa	.520	—0.017	—0.149	SE	22	12	98.5	34	10	Nil.	Overcast.

* For abbreviations see footnote in page 419.

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TABLE XV.—10 A.M., 8th June 1887.—concluded.

STATION.	Barometer.	Change in 24 hours.	Abnormal.	WIND.		Thermometer.	Relative humid- ity.	Cloud.	Rain- fall.	Remarks on the weather at 10 A.M.	
				Direction.	VELOCITY.						
					At 10 A.M.						Mean of day.
					Miles per hour.	Miles per hour.	°	Per cent.	0 to 10		
Indore . .	29'536	+ '037	- '135	SE	8	5	92'3	38	2	0'08	Cloudy.
Akola . .	'612	+ '037	- '079	SSE	9	6	90'5	45	8	Nil.	Ditto.
Malegaon . .	'590	+ '019	- '111	SE	13	5	85'5	57	10	Nil.	Overcast.
Poona . .	'593	- '002	- '175	SE	10	7	82'8	62	5	Nil.	Cloudy.
Sholapur . .	'614	0	- '145	SSE	10	10	87'8	48	7	0'51	Ditto.
Belgaum . .	'638	+ '010	- '186	S	33	26	70'8	93	10	0'37	Overcast.
Bellary . .	'671	- '021	- '116	SW	...	13	87'3	49	8	0'04	
Bangalore . .	'806	+ '004	- '023	SW	...	8	71'7	55	9	0'04	Drizzling rain.
Salem . .	'807	- '015	- '044	SW	...	3	79'5	70	8	0'08	Very clear.

TABLE XVI.—8th June 1887.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Akbar</i> . .	1 A.M.	...	...	W	...	Heavy squall of wind and rain.
	4 A.M.	...	...	WNW	...	
	5 A.M.	...	...	Variable	...	Heavy squalls of wind and rain with high cross sea. Ship pitching and rolling.
	6 A.M.	...	...	WSW	...	
	7 A.M.	...	...	SW	...	
	8 A.M.	...	...	S	...	Less wind and sea. Heavy rain squalls.
	Noon	29'498	...	...	...	Same weather. Lat. 18 34' N. Long. 71° 17' E. Course N 77° E. Distance 244 miles.
	1 P.M.	...	...	S	...	
<i>S. S. Albany</i> . .	4 P.M.	...	...	SSE	...	Strong wind and sea with rain.
	Noon	...	...	SW	...	Lat. 15° 21' N. Long. 53° 4' E. Course N 64° 41' E. Distance 255 miles. Fresh wind and very hazy weather. Heavy southerly swell veering to SW.
<i>S. S. Assam</i> . .	1 A.M.	...	...	SE	...	
	2 A.M.	...	...	...	5	Fresh wind and confused sea. Ship rolling and taking sprays over fore and aft. Drizzling rain at times.
	4 A.M.	29'376	85'7	...	6	
	8 A.M.	...	82'7	...	7	Moderate gale and high confused sea. Ship pitching and taking water over fore and aft.
	10 A.M.	...	...	SSE	...	
	Noon	29'366	82'7	...	6	Lat. 18° 13' N. Long. 69° 20' E. Course various. Distance 204 miles. Decreasing wind and overcast. Ship labouring to confused south-westerly and south-south-easterly sea, and shipping large quantities of water. Drizzling rain.

TABLE XVI.—8th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
S. S. Assam—continued.	1 A.M.	29.286	...	SE	...	
	2 A.M.	29.206	...	...	...	
	3 P.M.	29.166	...	ESE	...	
	4 P.M.	29.106	81.7	...	9	Strong gale with high confused sea. Shipping large quantities of water.
	5 P.M.	29.116	...	...	...	
	6 P.M.	29.096	...	...	9	Strong gale with frequent squalls of hurricane force and driving rain. Very high confused sea. Shipping much water.
	7 P.M.	29.076	...	ENE	...	
	8 P.M.	29.066	80.7	NE to N by E.	...	Every appearance of an approaching cyclone to southward. At 8.30 P.M., shipping heavy seas fore and aft with a continuous driving spray sweeping over the ship. Wind shifted to northward. Ship evidently in the right hand semicircle of a cyclone to the southward of our position and apparently crossing our track.
	10 P.M.	29.016	...	N by E to NE.	...	
	Midnight	28.916	82.7	ENE to ESE.	1	At 11.45, P.M., wind fell quite light with vivid lightning all round. Barometer still falling and a very confused sea running.
S. S. Chanda	1 A.M.	...	...	SSW	...	
	3 A.M.	...	...	SE	...	
	4 A.M.	29.713	84.0	...	...	Moderate breeze and squally with heavy rain.
	7 A.M.	...	...	NW	...	Light breeze with high swell. Sky overcast.
	8 A.M.	29.743	80.0	...	...	Moderate breeze and rainy weather.
	10-20 A.M.	...	...	...	...	Thick rainy weather. Heavy sea.
	11 A.M.	...	...	Variable	...	
	Noon	29.713	80.0	...	...	Lat. 11° 49' N, Long. 75° 16' E. Weather thick and hazy with heavy squalls.
	1 P.M.	...	...	SW to WSW.	...	
	4 P.M.	29.713	81.0	SW to WSW.	...	Moderate breeze and drizzling rain. Heavy beam sea. Ship lurching heavily.
S. S. Clan Forbes	8 P.M.	29.723	84.0	SW to WSW.	...	Moderate breeze and hard squalls. Heavy beam sea. Ship lurching and pitching heavily and taking in water fore and aft.
	Midnight	29.743	82.0	SW to WSW.	...	Fresh breeze and thick rainy weather. Heavy beam sea. Ship lurching very heavily at times.
	1 A.M.	...	...	SW	...	Strong wind. Clear weather. Heavy SW sea. Ship labouring and flooding decks with water.
	4 A.M.	29.532	83.5	SW	...	Wind and weather as above.
	8 A.M.	29.602	84.5	SW	...	Strong wind. Clear. Following sea.
	Noon	29.582	85.5	SW	...	Lat. 16° 17' N, Long. 62° 28' E. Course N 81° E. Distance 238 miles. Moderate wind. Passing clouds and following sea.
	1 P.M.	...	...	WSW	...	Moderate wind. Passing clouds and following sea.
	3 P.M.	...	...	WSW	...	Increasing wind.
	4 P.M.	29.532	89.5	WSW	...	Strong wind. Dull. Cloudy. Overcast.
	8 P.M.	29.522	89.5	WSW	...	Ditto ditto. Passing light showers.

THE ARABIAN SEA CYCLONE OF

TABLE XVI.—8th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Clam Forbes—</i> <i>contd.</i>	10 P.M.	...	...	WSW	...	Wind increasing to moderate gale.
	Midnight	29.402	85.5	WSW	...	Fresh and increasing gale. Rising sea.
<i>S. S. Colaba</i>	2 A.M.	...	...	SE	...	Wind shifting to SE.
	4 A.M.	29.491	77.8	S	...	Moderate wind and continuous heavy rain.
	8 A.M.	29.582	80.8	SE	...	
	Noon	...	...	...	...	At Bombay. Moderate breeze and cloudy.
	4 P.M.	29.510	81.8	S	...	
<i>S. S. Darien</i>	1 A.M.	...	...	SW	...	Strong SW monsoon. Cloudy weather.
	8 A.M.	29.585	...	...	...	
	Noon	...	90.0	...	...	Lat. 14° 49' N, Long. 54° 18' E. Course ENE.
	8 P.M.	29.585	...	...	...	Distance 250 miles.
	Midnight	...	90.0	...	...	
<i>S. S. Deekan</i>	1 A.M.	...	...	SE	5	
	4 A.M.	29.504	81.5	SE	5	Fresh breeze and overcast squally weather.
	7 A.M.	...	...	S by W	...	
	8 A.M.	29.542	82.5	...	...	
	Noon	29.549	83.5	...	...	At Bombay.
	1 P.M.	...	...	SSW	...	
	4 P.M.	29.572	82.5	...	...	
	8 P.M.	29.574	82.5	...	...	
	Midnight	29.687	80.5	...	...	
	4 A.M.	...	...	WSW	...	Strong wind with high confused sea. Thunder and lightning and heavy rain. Ship labouring heavily and shipping water fore and aft.
<i>S. S. Draco</i>	2 A.M.	28.858	...	...	...	Ditto ditto.
	4 A.M.	...	...	...	...	Ditto ditto.
	5 A.M.	...	...	SW	...	Ditto ditto.
	6 A.M.	29.358	...	SW	...	Wind hauled more southerly.
	8 A.M.	...	...	S	...	Ditto ditto.
	9 A.M.	...	...	SE	...	Fresh wind and rain. Less sea.
	Noon	29.458	...	SSE	...	Fresh wind and rain squalls.
	4 P.M.	...	...	ESE	...	Lat. 18° 34' N, Long. 71° 27' E. Course N 80° E. Distance 185 miles. Fresh SSE breeze and passing showers.
	8 P.M.	...	...	SSE	...	Same weather.
	Midnight	...	...	SSE	...	Strong wind with beam sea. Ship rolling heavily and taking water on board fore and aft.
<i>S. S. Germania</i>	1 A.M.	...	...	...	...	Strong wind with confused sea. Shipping water fore and aft.
	2 A.M.	...	...	N	...	Light airs and clear weather.
	8 A.M.	...	...	...	...	Light wind and hazy weather.

TABLE XVI.—8th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Germania</i> —contd.	70 A.M.	...	...	NW	...	Lat. 12° 6' N, Long. 43° 36' E. Course S 38° E. Distance 233 miles. Moderate breeze and thick hazy weather.
	Noon	...	...	...	...	
	4 P.M.	...	...	W	...	
	8 P.M.	...	...	W	...	
<i>S. S. Giava</i>	1 A.M.	...	82.4	SSW	...	Moderate wind and hazy weather up to mid- night. Lat. 16° 33' N, Long. 63° 49' E. Course N 74° E. Distance 240 miles.
	5 A.M.	...	84.2	SSW	...	
	9 A.M.	...	84.2	SSW	...	
	Noon	...	...	...	...	
	1 P.M.	29.600	84.2	SSW	8	
	5 P.M.	29.400	82.4	SSW	10	
	9 P.M.	29.200	80.6	SSW	10	
	Midnight	...	...	...	...	
	1 A.M.	...	...	ESE	...	
<i>S. S. Henry Bolckow</i>	4 A.M.	29.483	82.5	...	...	Tremendous sea. Tempest of wind and rain. Constant squalls. Light breeze and fine weather. Ship rolling to heavy swell. Fine weather. Hazy horizon. Rising sea from south. Light airs with heavy SE swell. Lat. 20° 40' N, Long. 64° 30' E. Course N 87° E. Distance 194 miles. Light variable winds and fine with a heavy SE swell. Hazy weather. Rising sea. Light airs with cloudy sky. Swell from south.
	8 A.M.	29.523	81.5	Calm	...	
	9 A.M.	...	...	...	...	
	Noon	29.533	84.5	Variable	...	
	2 P.M.	...	...	Variable	...	
	4 P.M.	29.533	87.5	Variable	...	
	5 P.M.	...	...	Calm	...	
	8 P.M.	29.563	92.5	...	...	
	9 P.M.	...	...	...	...	
	Midnight	29.523	82.5	...	...	
<i>S. S. Java</i>	1 A.M.	...	...	Variable	...	Moderate breeze with hazy weather. Ditto ditto. Ditto ditto. Ditto ditto. Lat. 24° 38' N, Long. 61° 0' E. Course N 65° E. Distance 146 miles. Fine calm hazy weather. Fine calm hazy weather.
	4 A.M.	29.447	80.1	...	...	
	8 A.M.	29.467	84.0	...	...	
	9 A.M.	...	...	SE	...	
	Noon	29.487	84.0	...	...	
	1 P.M.	...	...	Calm	...	
	4 P.M.	29.517	89.1	Calm	...	
	8 P.M.	29.497	86.1	Calm	...	
<i>S. S. Kangra</i>	6 A.M.	...	...	SW	2	At Karachi.
	Noon	29.514	85.1	SW	2	
<i>S. S. Kohinur</i>	2 A.M.	...	...	SW	2	Light breeze. Rainy weather. Heavy westerly swell. Light breeze and cloudy with passing showers.
	4 A.M.	...	...	SSE	...	
	5 A.M.	...	...	...	...	

THE ARABIAN SEA CYCLONE OF

TABLE XVI.—8th June 1887—continued.

NAME OF VESSEL.	HOUR.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Kohinur</i> —contd.	Noon	...	...	...	...	At Allepi.
	2 P.M.	...	...	SW	2	Fine weather, cloudy. Heavy westerly swell.
	6 P.M.	...	...	Variable	...	At 8 P.M. light wind and overcast.
	10 P.M.	...	...	Variable	...	Moderate sea.
	Midnight	...	...	Variable	...	Light breeze. Sky overcast and thick haze all round the horizon.
<i>S. Lorna Doone</i>	Noon	29'550	...	WNW	...	Lat. 18° 29' N, Long. 64° 12' E. Fresh to strong gale.
<i>S. S. Nisam</i>	1 A.M.	...	...	SE	2	Light wind and fine weather.
	4 A.M.	29'537	84'3	S to SW	...	Moderate wind and fine weather.
	8 A.M.	29'589	87'3	S to SW	...	Ditto ditto. Hazy horizon.
	Noon	29'629	91'3	S to SW	...	Lat. 13° 12' N, Long. 49° 25' E. Course various. Distance 265 miles. Moderate following wind with considerable sea.
	1 P.M.	...	...	SW to W	4	
	4 P.M.	29'633	...	SW to W	5	Fresh following wind and fine weather.
	8 P.M.	29'520	...	SW to W	5	Fresh unsteady wind and fine.
	9 P.M.	...	...	SE	2	
	10 P.M.	...	...	SE	3	
	11 P.M.	...	...	SE	4	
	Midnight	29'555	84'3	SE	4	Moderate wind and fine weather. Ship rolling heavily at times to heavy southerly swell.
	1 A.M.	...	...	WSW	4	
	4 A.M.	29'847	83'5	Variable	1	At Tuticorin. Light airs and fine.
<i>S. S. Nurjahan</i>	8 P.M.	...	...	...	...	Moderate breeze and cloudy.
	9 P.M.	...	...	SW	4	Sea smooth.
	Midnight	29'827	82'5	SW	5	Fresh breeze with clear weather.
	4 A.M.	29'592	...	ESE	6	
	8 A.M.	29'642	...	SE	6	At Bombay.
<i>S. S. Oswald</i>	9 A.M.	...	...	SW to W	...	Strong wind and high sea. Ship rolling heavily and shipping water.
	4 A.M.	29'616	84'5	...	...	
	8 A.M.	29'643	85'2	...	...	Strong wind and cloudy.
	9 A.M.	...	...	WSW	...	
	Noon	...	...	WSW	...	Lat. 16° 16' N, Long. 62° 8' E. Course N 76° E. Distance 225 miles. Wind and sea moderated.
	1 P.M.	29'628	87'1	WSW	...	
	4 P.M.	...	...	WSW	...	Fresh breeze with lightning.
	7 P.M.	29'603	85'1	WSW	...	
	Midnight	29'542	82'1	WSW	...	Wind and sea increasing with heavy squalls and torrents of rain.
	1 A.M.	...	...	SW	...	Strong gale and heavy rain.
<i>S. S. Panama</i>	Noon	...	...	SW	...	Ditto ditto. Lat. 18° 11' N, Long. 71° 51' E. Course ENE. Distance 196 miles.

TABLE XVI.—6th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Panama</i> —contd.	1 P.M.	...	...	S	...	
	4 P.M.	...	...	S	...	Strong breeze and showery.
	8 P.M.	...	...	S	...	Strong breeze and rain.
<i>S. S. Persia</i>	1 A.M.	29.672	88.2	N	1 to 2	Light wind and foggy.
	5 A.M.	29.672	89.1	N	2 to 3	Moderate breeze and foggy.
	7 A.M.	29.702	89.1	N	2 to 3	Ditto ditto.
	9 A.M.	29.672	91.1	N	2 to 3	
	11 A.M.	29.672	92.1	N	2	At 10 A.M. thick fog.
	Noon	...	...	N	4	Lat. 12° 34' N, Long. 43° 40' E. Course various.
	1 P.M.	29.672	93.1	N	4	Distance 246 miles.
	5 P.M.	29.672	92.1	W	4	
	7 P.M.	29.672	91.1	E	2	At 4 P.M. fresh breeze and foggy.
	9 P.M.	29.652	90.1	Variable	4 to 2	
	11 P.M.	29.652	89.1	Variable	3	
	Midnight	...	...	E	4	Fresh breeze and clear weather.
<i>S. S. Rockliff</i>	1 A.M.	...	...	SSW	...	Strong breeze. Hazy. Sea heavy. Shipping water continually over all.
	Noon	...	...	SSW	...	Ditto ditto.
	Midnight	...	...	SSW	...	Lat. 16° 11' N, Long. 59° 8' E. Course N 76½° E. Distance 216 miles.
<i>S. S. Rothsay</i>	1 A.M.	...	...	SSE	...	
	2 A.M.	...	...	SSE	...	Ship rolling heavily to heavy southerly swell.
	4 A.M.	...	...	SSE	...	Steady breeze and hazy close weather.
	7 A.M.	...	...	S	...	At 8 A.M. Steady breeze. Southerly swell.
	Noon	29.623	...	S	...	Rolling heavily and shipping water freely.
						Lat. 12° 57' N, Long. 52° 57' E. Course N 88° E. Distance 136 miles.
						At 11 A.M. shipped a heavy sea.
	2 P.M.	...	...	S by W	...	
	3 P.M.	...	...	S by W	...	Heavy sea and strong breeze. Ship listed heavily to port.
	6 P.M.	...	...	S by W	...	Weather moderate.
<i>S. S. Satara</i>	10 P.M.	...	...	S by W	...	Strong breeze with heavy squalls.
	Midnight	...	...	S by W	...	Weather unsettled and threatening.
	4 A.M.	29.510	84.3	NW	...	Moderate breeze and overcast.
	8 A.M.	29.505	86.3	N by W	...	Westerly swell.
	Noon	29.480	88.3	N by W	...	Moderate breeze and fine weather.
<i>S. S. Victoria</i>	1 P.M.	...	...	NW	...	
	5 P.M.	29.537	89.3	NW	...	Light breeze and fine weather.
	8 A.M.	...	...	WSW	...	Fresh breeze with a heavy SW sea and overcast sky. Ship taking water on board fore and aft.
	Noon	...	...	WSW	...	Ditto ditto.
						Lat. 17° 15' N, Long. 62° 22' E. Course S 79° W. Distance 182 miles.
	8 P.M.	...	...	...	...	Weather and wind as at noon.

THE ARABIAN SEA CYCLONE OF

TABLE XVI—8th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Britannia</i>	1 A.M.	...	...	SW & W	5	Strong breeze and cloudy, but fair weather.
	4 A.M.	29.708	76.4	SW & W	5	High sea. Shipping much water. Ditto ditto.
	7 A.M.	...	...	SW & W	5	Moderate gale. Passing clouds.
	8 A.M.	29.758	74.4	SW & W	5	Very heavy head sea.
	Noon	29.768	74.4	SW & W	6	Lat. 8° 3' N, Long. 58° 45' E. Course N 64° W. Distance 159 miles.
	4 P.M.	29.728	78.4	SW & W	6	Moderate gale. Very heavy head sea. Shipping much water fore and aft.
	8 P.M.	29.698	74.4	SW & W	6	Moderate gale. High sea. Hazy weather.
	Midnight	29.718	74.4	SW & W	6	Ditto ditto.
<i>S. S. Clan Graham</i>	1 A.M.	...	...	W	...	At 2 A.M. fresh wind and cloudy sky. Ship rolling and pitching and shipping heavy water at times.
	4 A.M.	29.558	87.8	...	...	High swell from west south-westward.
	8 A.M.	29.625	88.8	...	...	Fresh head wind. Vessel plunging heavily to head sea and shipping much water.
	Noon.	29.602	89.8	...	...	Ditto ditto.
	1 P.M.	...	...	W	...	Lat. 18° 15' N, Long. 62° 54' E. Course S 86° W. Distance 178 miles.
	4 P.M.	29.652	89.8	...	...	Fresh wind and cloudy sky. Ship rolling and pitching to high swell from WSW, and shipping much water.
	8 P.M.	29.635	88.8	...	...	Ditto ditto.
	Midnight	29.617	87.8	...	...	Ditto ditto.
<i>S. S. Eden Hall</i>	1 P.M.	...	...	S	...	At Bombay. Strong wind and overcast sky.
	2 P.M.	29.833	86.6	...	...	
	3 P.M.	...	...	SW by S	...	
	4 P.M.	29.413	86.6	SW	...	At 5 P.M. strong breeze and rising sea.
	8 P.M.	29.473	87.6	SW	...	Ship labouring heavily, and shipping large quantities of water fore and aft.
	9 P.M.	...	...	S	...	
	10 P.M.	29.493	85.6	S	...	
	Midnight	29.493	85.6	S	...	Strong wind and squally with rain, and gloomy weather, and high SW sea. Ship rolling and straining heavily and shipping a large quantity of water on board, fore and aft.
<i>S. S. Etolia</i>	4 A.M.	...	...	S	...	At Bombay. Fresh breeze and cloudy weather.
	Noon.	29.540	...	...	...	Fresh breeze and overcast.
	1 P.M.	...	...	SE	...	
	3 P.M.	...	...	SE	...	Fresh breeze, confused sea. Shipping heavy water over the bows.
	9 P.M.	...	...	S	...	Ditto ditto.
	Midnight	...	...	S	...	Fresh breeze and overcast. Heavy head sea. Shipping heavy water over the bows.
<i>S. S. Sumatra</i>	2 A.M.	29.434	80.0	NW	...	Heavy squalls of rain and wind.
	4 A.M.	29.434	...	...	...	Fresh to strong wind with rain. Heavy squalls accompanied with lightning. Ship pitching heavily to NW swell.
	6 A.M.	29.434	...	...	...	

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TABLE XVI.—8th June 1887.—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Sumatra</i> —contd..	8 A.M.	29.434	...	...	...	
	10 A.M.	29.355	...	...	...	Moderate gale with very heavy squalls of wind and rain.
	Noon	29.305	...	...	...	Lat. 17° 41' N, Long. 67° 41' E. Course N 77° W. Distance 166 miles.
						Fresh gale. High head sea. Heavy squalls with very heavy seas. Very thick weather.
	1 P.M.	...	...	W	...	
	2 P.M.	29.205	...	...	...	Strong gale with terrific squalls of wind and rain. Ship labouring heavily.
	4 P.M.	29.305	...	...	...	
	6 P.M.	29.205	...	...	...	Violent gale and blinding rain.
	8 P.M.	29.355	...	...	...	Ship labouring heavily, and shipping large quantities of water fore and aft.
	9 P.M.	...	...	W	...	
<i>S. S. Hydaspes</i>	11 P.M.	...	...	...	...	Same weather. Ship labouring heavily.
	Midnight	29.125	...	...	...	
	1 A.M.	...	...	SW	5	
	4 A.M.	29.737	78.9	SW	5	Strong monsoon and high sea with hard squalls. Pitching heavily, and shipping much water.
	8 A.M.	29.719	81.9	SW	5	Strong monsoon and cloudy. High sea. Ship pitching heavily, and shipping large quantities of water.
	Noon	29.766	82.9	SW	6	Ditto ditto.
						Lat. 9° 25' N, Long. 65° 42' E. Course N 86° W. Distance 206 miles.
	4 P.M.	29.712	80.9	SW	6	Strong monsoon, and fine. High sea. Pitching heavily, and shipping much water.
	8 P.M.	29.749	81.9	SW	6	Strong monsoon, and cloudy. Ship pitching heavily to high sea, and shipping much water.
	Midnight	29.742	80.9	SW	6	Ditto ditto.
<i>S. S. Assyria</i>	8 A.M.	29.455	84.5	W by N	...	At Bunder Abbas. Light breeze and fine weather.
	Noon	29.455	83.8	SW	...	
	4 P.M.	29.425	88.5	W by S	...	Near Linga.
	Midnight	29.435	84.5	Calm	...	Fine clear weather.
<i>S. S. Clan Matheson</i>	4 A.M.	29.638	83.0	SW	7	Strong monsoon. Sky heavily clouded. Very high sea.
	8 A.M.	29.638	83.0	SW	7	Ditto ditto.
	Noon	29.663	85.0	SW	7	Ditto ditto.
	4 P.M.	29.636	84.0	SW	7	Lat. 12° 52' N, Long. 55° 34' E.
	8 P.M.	29.656	84.0	SW	7	
	Midnight	29.686	84.0	SW	8	Same weather accompanied by hard squalls and rain.
						Moderate to strong gale with high sea.
<i>S. S. Fumina</i>	4 A.M.	29.782	75.0	SW	5	
	8 A.M.	...	...	SW	8	Ditto ditto.
	Noon	...	...	SW	8	Lat. 9° 28' N, Long. 59° 50' E. Distance 194 miles.
						Fresh gale with high sea. Shipping tons of water.
	4 P.M.	29.784	74.0	SW	9	Strong gale and high sea.
	8 P.M.	29.754	74.0	SW	9	Strong gale with violent squalls.
	Midnight	29.734	74.0	SW	8	Strong gale with hard gusts.

THE ARABIAN SEA CYCLONE OF

TABLE XVI.—8th June 1887—concluded.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Mecca</i>	4 A.M.	29.704	...	...	...	Fresh wind and moderate sea. Sky overcast with occasional heavy wind and rain squalls.
	8 A.M.	29.894	...	...	...	Moderate breeze and clear with confused sea.
	Noon	29.904	...	...	...	Lat. 0° 10' S, Long. 50° 0' E. Distance 149 miles.
	4 P.M.	29.844	...	SSW to SW	...	Weather unsettled. Sea very confused with a high prevailing westerly swell. Squally towards the horizon, with occasional light rain showers.
	8 P.M.	29.854	...		...	
	Midnight	29.924	...	...	...	Fresh breeze, with heavy confused sea. High prevailing south-west swell. Very heavy and continuous squalls with torrents of rain. Weather dull and cloudy.
<i>S. S. Nazarino</i>	4 A.M.	29.668	88.0	SW	5	Strong breeze and squally, with rain.
	8 A.M.	29.718	90.0	SW	5	Moderate breeze and squally, with rain.
	Noon	29.708	90.0	SW	5	Lat. 10° 44' N, Long. 65° 50' E. Distance 275 miles.
	4 P.M.	29.688	90.0	SW	5	Fresh monsoon, and cloudy weather.
	8 P.M.	29.718	90.0	SW	5	Fresh monsoon weather.
	Midnight	29.708	90.0	SW	5	Moderate gale and clear weather.
<i>S. R. Morrow</i>	1 A.M.	...	...	W	...	Fresh monsoon and fine, with passing clouds. Lightning to S-W.
	4 A.M.	...	...	Variable	...	
	9 A.M.	...	...	SSE	...	
	Noon	...	...	SSE	...	Lat. 18° 10' N, Long. 71° 52' E. Course S 27° W. Distance 116 miles.
	1 P.M.	...	...	SSW	...	
	5 P.M.	...	...	S	...	
	Midnight	...	...	S	...	Hard squalls with rain.

TABLE XVII.—10 A.M., 9th June 1887.

STATION.	Barometer.	Change in twenty four hours.	Abnormal.	WIND.			Thermometer.	Relative humidity.	Cloud.	Rain-fall.	Remarks on the weather at 10 A.M.
				Direction.	VELOCITY.						
					At 10 A.M.	Mean of day.					
"	"	"	"	"	"	"	°	Per cent.	° to 10.	"	
Aden	29.680	+0.034	...	SW	...	8	89.6	73	0	Nil.	
Bushire	538	+0.06	...	NW	...	...	88.8	66	?	Nil.	
Kurrachee	567	+0.068	-0.074	E	11	14	92.5	56	2	Nil.	Fine weather with passing clouds.
Bhuj	584	+0.069	-0.065	SE	20	11	89.2	59	5	0.63	Cloudy.
Rajkot	588	+0.070	-0.091	SE	5	7	90.1	56	4	0.03	Ditto.
Surat	660	+0.103	-0.076	SW	F*	...	90.0	58	5	Nil.	Fine weather with passing clouds.
Bombay	686	+0.133	-0.095	SE	28	29	82.4	78	10	0.01	Ditto. High sea.
Ratnagiri	729	+0.135	-0.072	SE	12	16	80.3	87	9	1.52	Ditto.

* For abbreviations see foot-note in page 419.

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TABLE XVII.—10 A.M., 9th June 1887—concluded.

STATION.	Baro- meter.	Change in twenty- four hours.	Abnormal.	WIND.		Thermo- meter.	Rela- tive humid- ity.	Cloud.	Rain- fall.	Remarks on the weather at 10 A.M.	
				Direction.	VELOCITY.						
					At 10 A.M.						Mean of day.
	"	"	"		Miles per hour.	Miles per hour.	°	Per- cent.	0 to 10.	"	
Karwar . . .	789	+122	-043	SW	S*	...	78.1	89	10	2.28	Strong wind.
Mangalore . .	29.849	+085	-005	ESE	2	5	73.5	98	10	4.56	Sea tremendous.
Calicut . . .	855	+023	-029	SE	5	5	75.6	92	10	3.34	Raining.
Cochin . . .	877	+019	-020	ESE	...	...	80.5	80	9	1.43	
Colombo . . .	889	+031	...	SSW	...	7	82.0	73	7	0.10	
Galle . . .	877	+027	...	WNW	6	8	80.0	96	7	0.10	
Jacobabad . .	527	+025	-016	ESE	5	4	109.2	13	0	Nil.	Dust haze.
Hyderabad (Sind)	559	+061	-014	SSE	4	8	102.1	22	0	Nil.	Blue sky.
Neemuch . . .	636	+046	0	S	...	...	90.8	62	0	0.70	Ditto.
Deesa . . .	639	+119	-027	SSE	10	16	91.8	52	10	Nil.	Overcast.
Indore . . .	593	+057	-076	SW	6	5	92.3	41	2	0.02	Cloudy.
Akola . . .	671	+059	-018	SW	8	7	91.4	44	3	Nil.	Ditto.
Malegaon . . .	668	+078	-031	WSW	7	7	85.0	55	2	Nil.	Ditto.
Poona . . .	741	+148	-036	SW	6	6	79.7	68	9	0.01	Ditto.
Sholapur . . .	746	+132	-013	WSW	13	11	82.3	61	8	Nil.	Ditto.
Belgaum . . .	746	+108	-078	SSW	30	28	72.8	83	10	0.33	Fine.
Bellary . . .	768	+097	-019	SW	...	14	84.8	52	8	Nil.	
Bangalore . .	878	+062	+048	W	...	8	72.7	81	9	Nil.	Gloomy.
Salem . . .	854	+047	+003	SW	...	5	82.0	71	4	Nil.	Fine.

* For abbreviation see foot-note in page 419.

TABLE XVIII.—9th June 1887.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	WIND.		REMARKS.
				Direction.	Force.	
S. S. Albany . .	Noon	...	...	SW	...	Lat. 17° 11' N, Long. 57° 24' E. Course N 66° E. Distance 273 miles. Fresh wind. Very hazy.
S. S. Azam . . .	1 A.M.	28.956	...	SE	...	At 0 h. 15' A.M. sudden shift of wind to SE. Sea very much confused. At 0 h. 30' A.M., blowing again with terrific force.
	2 A.M.	29.006	...	SSE	...	At 2.30 A.M., hard squalls of hurricane violence. Heavy seas breaking over ship fore and aft.
	3 A.M.	29.166	...	S	...	At 3.30 A.M. decreasing wind, storm having crossed our position to the WNW.
	4 A.M.	29.256	81.7	SSW	...	
	5 A.M.	29.306	...	...	...	
	6 A.M.	29.326	...	...	...	
	7 A.M.	29.366	...	...	...	
	8 A.M.	29.396	80.7	SW	...	Decreasing wind. High sea. Shipping heavy bodies of water.
	10 A.M.	29.416	...	S	...	

THE ARABIAN SEA CYCLONE OF

TABLE XVIII.—9th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	Wind.		REMARKS.
				Direction.	Force.	
S. S. Assam—contd.	Noon	29'396	81'7	S	5	Lat. 18° 59' N. Long. 66° 16' E. Course various. Distance 176 miles. Weather clearing up with passing squalls of rain. Very high south-westerly sea. Ship labouring heavily, and shipping heavy seas fore and aft.
	1 P.M.	...	...	SSW	...	
	2 P.M.	29'356	...	SSW	...	
	4 P.M.	29'346	79'7	SSW	8	Moderate increasing gale, and overcast, with very high confused sea. Ship labouring heavily, and shipping large quantities of water.
	6 P.M.	29'336	...	SSW	8	
	8 P.M.	29'306	83'7	SSW	9	Strong gale with hard squalls. Ship labouring and shipping water.
	10 P.M.	29'336	...	S	10	A hard gale with squalls of hurricane violence. A tremendous confused sea running and breaking on board in large quantities with heavy force.
	Midnight	29'366	88'7	S by W	8	Weather improving.
	8 A.M.	29'627	82'6	W	...	At Bombay. Fresh breeze, and passing showers.
	8 P.M.	29'707	84'6	SW	...	Fresh breeze and heavy sea.
S. S. Canara	Midnight	29'717	84'6	SW	...	Heavy head sea. Ship pitching heavily. Dull cloudy weather.
	1 A.M.	...	...	SW	...	
S. S. Chanda	3 A.M.	...	...	SSW	...	
	4 A.M.	29'723	80'0	...	...	Strong breeze and squally, with thick rain. High beam sea. Ship rolling and pitching heavily.
	6 A.M.	...	...	Variable	...	
	8 A.M.	29'733	82'0	...	...	Heavy squalls of wind and rain. Very heavy beam sea. Ship pitching and lurching heavily.
	9 A.M.	...	...	SW to W	...	
	11 A.M.	...	...	Variable	...	At 11:40 A.M. heavy rain. Sea very heavy.
	Noon	29'733	82'0	...	...	At Karwar.
	1 P.M.	...	...	SW	...	Continuous heavy rain and wind squalls.
	4 P.M.	29'743	85'0	...	...	Squally with high sea. Ship pitching and lurching heavily, shipping large quantities of water.
	8 P.M.	29'743	82'0	WNW to WSW	...	Light breeze. Sea as before.
	Midnight	29'723	82'0	WSW to WSW	...	Fresh breeze and overcast. Heavy W by S sea very high. Ship lurching heavily, decks flooded with water.
	1 A.M.	...	...	SSW	...	Fresh gale, thick hazy weather, overcast. Very high following sea.
	4 A.M.	...	79'5	SW	...	Wind continues to increase, blowing very hard.
S. S. Clan Forbes	6 A.M.	...	...	WSW	...	Terrific gale. Fierce mountainous sea. Ship labouring very badly, shipping large bodies of water fore and aft.
	8 A.M.	...	77'5	WSW	...	Wind and sea continue to increase. Wind blowing with hurricane force. Barometer falling.
	10 A.M.	...	...	SW	...	
	Noon	...	77'5	SSW	...	Lat. 12° 2' N. Long. 65° 5' E. Course N 72° E. Distance 247 miles.
	2 P.M.	...	...	SSW	...	Terrific gale. Mountainous cross sea. Terrific gale. Mountainous sea. At 1:30 P.M. sea terrific; decks full of water.

TABLE XVIII.—9th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Clan Forbes</i> —contd.	4 P.M.	...	79.5	SSW	...	Gale continues.
	8 P.M.	...	81.5	SSW	...	Weather improved. Clear.
	Midnight	...	81.5	SSW	...	Less wind, but sea very high.
<i>S. S. Darien</i>	1 A.M.	...	...	SW	...	Strong monsoon, rainy weather.
	Noon	...	90.0	...	...	Lat. 16° 3' N, Long. 58° 30' E. Course E. N. E. Distance 263 miles.
	6 P.M.	...	...	...	...	Steady monsoon, blowing strong.
	Midnight	...	90.0	...	...	At 11 P. M. barometer began falling, when suddenly the wind blew with terrific force, accompanied by heavy lightning. Blowing a hurricane. Sea breaking over the decks and upper bridge.
<i>S. S. Germania</i>	1 A.M.	...	...	...	...	Fresh wind and clear weather.
	2 A.M.	...	...	W	...	
	4 A.M.	...	...	W	...	Moderate winds and fine weather.
	Noon	...	...	W	...	Lat. 11° 57' N, Long. 46° 57' E. Course N 82° E. Distance 208 miles.
	8 P.M.	...	...	W	...	Light airs and clear weather.
<i>S. S. Giara</i>	Midnight	...	...	W	...	Ditto ditto. Moderate wind and clear weather.
	1 A.M.	29.000	80.6	SSW	10	
	5 A.M.	29.300	78.8	SSW	10	
	9 A.M.	29.400	80.6	SSW	8	
	Noon	...	...	...	...	Lat. 17° 50' N, Long. 68° 22' E. Course N 72° E. Distance 250 miles.
	3 P.M.	29.500	80.6	SSE	8	Fresh to moderate wind. Very high sea. Squall of rain.
	5 P.M.	29.600	80.6	SSE	6	
<i>S. S. Henry Bolckow</i>	9 P.M.	29.700	78.8	SSE	6	
	1 A.M.	...	...	SSE	...	Light variable winds and fine weather.
	4 A.M.	29.323	88.5	...	...	Southerly swell.
	8 A.M.	29.523	88.5	...	...	
	1 P.M.	...	...	Calm	...	At Kurrachee.
<i>S. S. Jaes</i>	8 P.M.	29.523	88.5	...	...	
	6 A.M.	...	...	Calm	...	
	8 A.M.	29.497	86.1	Calm	...	Light airs, with hazy weather.
	9 A.M.	...	...	E	...	
	Noon	29.527	87.1	...	...	Lat. 25° 0' N, Long. 63° 24' E. Course S 82° E. Distance 163 miles.
	1 P.M.	...	...	NE	...	Moderate breeze with hazy weather.
	4 P.M.	29.527	87.1	...	...	Moderate breeze with dull hazy weather and high swell.
<i>S. S. Kangra</i>	8 P.M.	29.527	84.4	...	...	Ditto ditto.
	Midnight	29.567	84.4	...	...	Ditto ditto.
	Noon	29.576	84.8	SW	2	Ship rolling heavily. At Kurrachee.
<i>S. S. Kohinur</i>	1 A.M.	...	...	Variable	2	Sea smooth.

TABLE XVIII.—9th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Kohinur</i> —contd.	4 A.M.	...	...	Variable	...	Heavy weather. Occasional showers.
	7 A.M.	...	...	SW	...	
	Noon	...	...	S	4 to 5	At Tuticorin.
<i>S. Lorna Doone</i> . .	1 A.M.	...	...	NW	...	Strong gale.
	2 A.M.	...	...	N	...	Gale increasing and hauling northerly. Barometer still falling. Every appearance of a cyclone.
	4 A.M.	29'460	...	NE	...	Wind increasing. Ship rolling and straining fearfully.
	Noon	29'420	...	NE	...	Lat. 19° 48' N, Long. 64° 33' E. Wind blowing with hurricane force.
	Midnight	29'860	...	NE	...	Ditto ditto. Heavy squalls. Sea very heavy and confused. Fresh wind and fine weather.
<i>S. S. Nizam</i> .	1 A.M.	...	...	S	5	
	4 A.M.	29'518	80'3	S	5	Fresh wind and fine weather. Considerable beam sea. Ship labouring and shipping water over all at times.
	5 A.M.	...	...	S by W to SSW	...	
	8 A.M.	29'550	79'3	SW by S	7	Moderate monsoon gale and high southerly sea. Ship labouring and rolling heavily and shipping much water. Hazy weather.
	Noon	29'607	80'7	SW by S	7	Moderate gale with high sea. Ship lurching heavily at times. Lat. 14° 29' N, Long. 54° 22' E. Course N 75° E. Distance 299 miles.
	1 P.M.	...	...	SW	7	Strong monsoon with high sea. Ship rolling heavily at times.
	4 P.M.	29'455	81'3	SW	7	Ditto ditto.
	8 P.M.	29'535	81'3	SW	7	Strong monsoon with heavy following sea.
	11 P.M.	...	...	...	...	Sky overcast.
	Midnight	29'568	80'3	SW	6	Moderate monsoon. Ship rolling to heavy sea.
<i>S. S. Nurjahan</i> .	1 A.M.	...	...	SW	4	Sea smooth.
	4 A.M.	29'817	80'5	WSW	5	
	8 A.M.	...	...	W by N	4	Light southerly swell.
	Noon	29'867	83'5	W by N	4	Lat. 8° 29' N, Long. 76° 48' E. Course various. Distance 236 miles.
	1 P.M.	...	...	WNW	4	Light airs and cloudy. Heavy westerly swell.
	4 P.M.	29'847	77'5	NW	3	Moderate breeze and squally.
	8 P.M.	29'857	79'5	NW	3	Gentle breeze and cloudy.
	Midnight	29'887	81'5	...	...	At Allepi. Light airs. Sky overcast.
<i>S. S. Oswald</i> .	1 A.M.	...	...	WSW	...	Moderate gale and high sea with hard squalls.
	2 A.M.	...	85'1	...	...	Hard increasing gale and heavy sea with furious squalls. Ship rolling heavily and shipping large quantities of water.
	4 A.M.	...	84'1	...	...	At 5 A.M. furious gale and mountainous sea with terrific squalls. Ship labouring and straining heavily and shipping huge volumes of water.
	6 A.M.	...	...	SW	...	
	8 A.M.	...	81'1	SW	...	Increasing wind and mountainous sea. The docks constantly flooded with the tops of the seas, removing and destroying everything moveable.

THE 4TH TO 13TH JUNE 1887.

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TABLE XVIII.—9th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Oswald</i> —contd.	40 A.M.	...	...	SW	...	Wind blowing with hurricane force and ship labouring and straining heavily.
	14 A.M.	...	...	SW	...	The sea seems worse than ever, the decks being continually under water.
	Noon	...	81.1	SW	...	Ditto ditto. Lat. 16° 48' N, Long. 64° 49' E. Course N 78° E. Distance 159 miles.
	4 P.M.	...	...	...	...	Barometer rising and wind moderating a little, but sea still running very high and flooding the decks.
	8 P.M.	...	...	SSW	...	Sea still running very high but weather improving.
	Midnight	...	...	...	...	Sea much smoother and wind moderating though still blowing very hard.
<i>S. S. Pachamba</i>	8 A.M.	29.550	85.5	...	...	At Kurrachi. Light breeze and hot sultry weather.
	6 P.M.	...	...	S by W	...	
	2 P.M.	29.600	84.5	...	...	Moderate breeze and clear with heavy swell. Ship rolling and pitching heavily.
	11 P.M.	...	...	SSE	...	
<i>S. S. Persia</i>	Midnight	29.600	85.5	...	...	Fresh breeze and heavy swell. Sky overcast.
	1 A.M.	...	88.1	SE	3 to 4	Fresh breeze and clear weather.
	3 A.M.	...	88.1	...	...	
	5 A.M.	...	89.1	SW	4	Moderate SW wind and hazy.
	7 A.M.	...	91.1	SW	4	Ditto.
	9 A.M.	...	95.1	SW	4	Ditto.
	11 A.M.	...	99.1	SW	4	
	Noon	...	...	SW	3	Lat. 13° 0' N, Long. 47° 22' E. Course N. 83° E. Distance 213 miles.
	4 P.M.	...	92.1	SW	3	Moderate breeze and clear weather.
	3 P.M.	...	97.5	SW	3	
	5 P.M.	...	95.1	SW	3	At 6 P.M. wind light and baffling.
	7 P.M.	...	93.7	Variable	1 to 2	At 8 P.M. light variable airs and hazy.
	9 P.M.	...	92.1	Variable	1 to 2	
	11 P.M.	...	92.5	Variable	1 to 2	
<i>S. S. Rockliff</i>	4 A.M.	...	...	SW	...	Strong wind and cloudy. Sea heavy.
	8 A.M.	...	...	SW	...	Moderate gale. Sea increasing with rain.
	Noon	...	...	SW	...	Lat. 47° 0' N, Long. 62° 49' E. Course N. 77° E. Distance 212 miles.
	1 P.M.	...	...	SW	...	
	2 P.M.	...	...	NW	...	Strong gale with a heavy sea which kept steamer's deck continually full of water fore and aft.
	4 P.M.	...	...	W	...	
	6 P.M.	...	...	SW	...	
	8 P.M.	...	...	SW	...	Wind increased to a hurricane with a very heavy cross sea.
	9 P.M.	...	...	SSW	...	Wind SSW up to midnight.
<i>S. S. Rothsay</i>	9 A.M.	...	...	SSW	...	
	2.30 A.M.	...	...	SSW	...	A terrific gale with high dangerous sea.

THE ARABIAN SEA CYCLONE OF

TABLE XVIII.—*9th June 1887*—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Rothsay</i> —contd.	4.30 A.M.	"	"	SSW	...	Ship lay in the trough of the sea and became unmanageable, refusing to answer her helm. Whole seas breaking over her, filling offices and lamp rooms. At 7 A.M. a lull.
	Noon	29.673	...	SSW	...	Lat. 43° 2' N, Long. 55° 30' E. Course E. Distance 173 miles. Ship scudding before the gale.
	4 P.M.	...	...	SSW	...	
	5 P.M.	...	...	SW	...	
	Midnight	...	...	SW	...	Wind increasing with mountainous sea running.
<i>S. S. Satara</i>	4 A.M.	...	...	NW	...	
	8 A.M.	29.539	88.3	Variable	...	At Karachi. Light breeze and fine weather.
	5 P.M.	...	...	Variable	...	
	6 P.M.	...	...	S	...	
	8 P.M.	29.595	86.3	S	...	Light breeze and fine weather.
<i>S. S. Tarpeia</i>	Midnight	29.535	86.3	S	...	Ditto ditto. Heavy beam swell.
	1 A.M.	...	...	SW	...	Light breeze with clear weather.
	4 A.M.	...	...	SW	...	Moderate breeze with hazy weather.
	Noon	...	...	SW	...	Lat. 12° 29' N, Long. 46° 46' E. Course S 86° E. Distance 116 miles. Fresh breeze with clear weather.
	7 P.M.	...	...	SW	...	Moderate breeze with clear weather. Hazy horizon.
<i>S. S. Victoria</i>	Midnight	...	...	SW	...	
	8 A.M.	...	...	WSW	...	Strong monsoon with a heavy sea and cloudy weather. Ship labouring and taking quantities of water on board fore and aft.
	Noon	...	...	...	...	Lat. 16° 41' N, Long. 59° 29' E. Course S 79° W. Distance 170 miles. Weather from 8 A.M. up to 3.4 P.M. unchanged.
<i>S. S. Britannia</i>	Midnight	...	...	SW	...	Wind increasing to a moderate breeze. Sea going down.
	1 A.M.	...	...	SW by W	6	Moderate gale. Heavy beam sea. Passing clouds. Ship labouring a great deal.
	4 A.M.	...	74.4	SW by W	6	Ditto ditto.
	8 A.M.	29.748	74.4	SW by W	6	Ditto ditto. Shipping water fore and aft.
	Noon	29.738	73.4	SW by W	6	Moderate gale. Heavy beam sea. Passing clouds. Ship labouring a great deal. Shipping water fore and aft.
<i>S. S. Clan Graham</i>	4 P.M.	29.698	74.4	SW by W	6	Lat. 10° 19' N, Long. 56° 58' E. Course N. 38½ W. Distance 174 miles.
	5 P.M.	...	...	SW by W	7	Wind increasing and sea rising. Shipping much water fore and aft.
	8 P.M.	29.708	74.4	SW by W	7	Fresh gale and squally. Hazy weather.
	Midnight	...	72.4	SW by W	7	Similar wind and weather.
	1 A.M.	...	...	W	...	At 2 A.M. fresh wind and overcast sky. Ship rolling and pitching to high swell and filling decks with water fore and aft.
<i>S. S. Clan Graham</i>	4 A.M.	29.588	87.8	...	...	
	6.15 A.M.	...	...	...	...	Strong wind and high head sea. Vessel labouring heavily and keeping her decks continually flooded with water.
<i>S. S. Clan Graham</i>	8 A.M.	29.578	87.8	...	...	Ditto ditto.

TABLE XVIII.—9th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Clan Graham</i> — contd.	Noon	29.575	88.8	...	...	Strong wind and high head sea. Vessel labouring heavily and keeping her decks continually flooded with water. Lat. 17° 32' N, Long. 60° 2' E. Course S. 75½° W. Distance 169 miles.
	1 P.M.	...	...	W	...	
	4 P.M.	29.548	87.8	...	...	Ship labouring heavily to high swell and decks full of water continual fore and aft. Strong wind. Weather dull and gloomy.
	8 P.M.	29.591	86.8	...	...	Ditto ditto.
	9 P.M.	...	...	...	...	Vessel plunging violently to heavy head sea and shipping much water, filling her forward decks.
	Midnight	29.505	88.8	...	...	Strong gale and high sea.
<i>S. S. Eden Hall</i>	1 A.M.	...	...	S	...	Fresh breeze, and overcast with continued rain and high head sea. Ship pitching and straining and taking large quantities of water on board, flooding the decks fore and aft.
	2 A.M.	29.483	84.6	..	...	
	4 A.M.	29.493	84.6	...	...	Heavy continuous rain from 4.30 to 5.30 A.M.
	6 A.M.	29.503	84.6	...	...	Moderate breeze and overcast. Sea coming more ahead.
	8 A.M.	29.503	84.6	W	...	Heavy rain, ship taking large quantities of water over the bows, completely filling the decks.
	10 A.M.	29.513	85.6	...	...	
	Noon	...	85.6	...	...	Lat. 18° 25' N, Long. 70° 21' E. Course S. 75° W. Distance 136 miles.
	1 P.M.	...	...	SW	...	Light unsteady breeze and overcast with high SW sea.
	2 P.M.	29.493	83.6	SW	...	Moderate breeze and overcast sky with high SW sea.
	4 P.M.	29.493	83.6	SW	...	At 2.30 P.M. squally with heavy rain and high head sea. Ship labouring heavily and taking large quantities of water on board over the bows.
	7 P.M.	...	...	...	...	Strong breeze and squally with rain and tremendous SW sea.
	8 P.M.	29.523	83.6	Variable	...	
	10 P.M.	29.523	83.6	..	...	
<i>S. S. Etolia</i>	Midnight	29.503	84.6	SW	...	Strong wind and squally with rain and high SW sea. Shipping large quantities of water over all.
	1 A.M.	...	...	S to SSE	...	Strong breeze. Heavy squalls. High confused sea. Ship driving heavily and taking heavy water over the bows.
	7 A.M.	...	...	S to SSE	...	Heavy sea shipped over the bows.
	8 A.M.	...	...	S to SSE	...	Brought ship's head to sea.
	9 A.M.	...	...	SSE	...	Light wind and high confused sea.
	Noon	...	...	SSE	...	Sea more moderate.
	1 P.M.	...	...	S to W by S	...	Lat. 18° 27' N, Long. 70° 0' E. Course S. 80° W. Distance 160 miles.
	4 P.M.	...	...	S to W by S	...	Moderate breeze and high confused sea. Shipping great quantities of water.
	8 P.M.	...	...	S to W by S	...	Fresh breeze and squally with high confused sea. Shipping heavy water over the bows fore and aft.
		...	...		...	Strong breeze and squally. Heavy head sea. Shipping heavy water.

THE ARABIAN SEA CYCLONE OF

TABLE XVIII.—9th June 1887.—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Etolia</i> —contd.	Midnight	"	"	W by S	...	Moderate breeze and squally. High confused sea.
<i>S. S. Sumatra</i>	2 A.M.	29.105	...	W	...	Shipping heavy water on decks.
	4 A.M.	29.205	...	...	...	Strong gale. Heavy squalls of wind and rain. Mountainous sea.
	6 A.M.	29.205	...	...	...	
	8 A.M.	29.305	...	...	...	Moderate gale. Confused high sea. Ship labouring heavily and shipping much water fore and aft.
	9 A.M.	...	...	S	...	Ditto ditto.
	10 A.M.	29.425	...	...	...	Ditto ditto.
	Noon	29.385	...	...	...	Ditto ditto.
						Lat. 18° 9' N. Long. 66° 47' E. Course N 55° W. Distance 105 miles.
	1 P.M.	...	...	SSW	...	
	2 P.M.	29.305	...	SSW	...	
	3 P.M.	...	...	SSW	...	Strong wind with heavy squalls of wind and rain.
	4 P.M.	29.385	...	SSW	...	Ship labouring heavily to high confused sea.
	6 P.M.	29.385	...	...	...	Ditto ditto.
	8 P.M.	29.385	...	...	...	Same weather. Ship labouring heavily and shipping water.
	10 P.M.	29.385	...	...	...	Ditto ditto.
<i>S. S. Hydaspes</i>	Midnight	29.385	...	...	...	Same weather. Ship rolling heavily and shipping large quantities of water.
	1 A.M.	...	...	SW by S	6	
	4 A.M.	29.732	80.9	SW by S	6	Hard squalls. Strong monsoon. High sea. Ship pitching heavily and taking much water.
	8 A.M.	29.762	80.9	SW by S	6	Strong monsoon and fine. Ship pitching heavily to high sea and shipping large quantities of water.
	10 A.M.	...	...	SW by W	7	
	Noon	29.749	81.9	SW by W	7	Lat. 9° 49' N. Long. 62° 33' E. Strong monsoon and hazy. Ship pitching and lurching to high sea and shipping much water.
	1 P.M.	...	...	SW	7	
	4 P.M.	29.682	80.9	SW	7	Strong monsoon and squally. Ship pitching to high confused sea and taking water over.
	8 P.M.	29.722	80.9	SW	7	Strong monsoon and squally. Ship pitching to high sea and shipping much water fore and aft.
	Midnight	29.734	79.9	SW	7 to 8	Strong monsoon gale and cloudy with furious squalls at times. Ship labouring heavily and shipping large quantities of water fore and aft.
<i>S. S. Assyria</i>	4 A.M.	...	...	SW	...	Eight wind and fine weather. Smooth sea.
	8 A.M.	29.435	110.5	E	...	Light breeze and fine weather.
	Noon	29.535	92.5	S	...	Lat. 26° 57' N. Long. 52° 31' E. Course various. Distance 132 miles.
	4 P.M.	29.535	90.5	W	...	Light wind. Fine weather. Smooth sea.
	8 P.M.	29.535	88.5	W	...	Light head breeze and hazy.
	10 P.M.	...	...	W	...	Clear horizon.
	Midnight	...	84.5	W	...	Light wind. Fine clear weather.

TABLE XVIII.—9th June 1887—concluded.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Clan Matheson</i>	4 A.M.	29.665	84.0	WSW	8	Strong monsoon accompanied by heavy rain, squalls and very high sea. Ship rolling and tossing about badly.
	8 A.M.	29.665	84.0	SW by W	8	Ditto ditto.
	Noon	29.673	85.0	SW by W	8	Ditto ditto. Lat. 11° 40' N, Long. 64° 25' E.
	4 P.M.	29.615	84.0	SW by W	8	Weather unchanged.
	8 P.M.	29.737	83.0	SW by W	8	Ditto ditto.
	Midnight	29.745	84.0	SW by W	8	Ditto ditto.
<i>S. S. Europa</i>	6 P.M.	...	...	S	...	Near Bombay. Strong breeze and heavy sea. Decks flooded fore and aft up to midnight.
<i>S. S. Jumna</i>	4 A.M.	29.668	76.0	SW	9	Strong gale with high sea and clear weather.
	8 A.M.	29.647	77.0	SW	10	Hard gale from SW.
	Noon	29.645	78.0	SW	9	Lat. 12° 24' N, Long. 55° 40' E. Distance 203 miles.
	4 P.M.	29.628	76.0	SW	10	Strong gale with hard gusts and very high sea.
	8 P.M.	29.633	74.0	SW	11	Strong gale with very high sea.
	Midnight	29.621	72.0	SW	11	Hard gale with high confused sea.
<i>S. S. Mecca</i>	4 A.M.	29.874	...	S, SSW, & SW	...	Strong gale with violent squalls and mountainous sea running.
	8 A.M.	29.884	...		...	Moderate breeze and cloudy. Sea confused, but going down.
	Noon	29.924	...		...	Lat. 1° 6' S, Long. 47° 1' E. Distance 194 miles.
	4 P.M.	29.874	...		...	Light wind with squally appearance. Sky overcast. Confused sea.
	8 P.M.	29.904	...		...	
	Midnight	29.924	...		...	Fresh breeze with moderate southerly swell and fine clear weather, but passing clouds at times.
<i>S. S. Navarino</i>	4 A.M.	29.708	90.0	SW	5	Moderate gale with hard squalls at times.
	8 A.M.	29.778	90.0	SSW	5	Ditto ditto.
	Noon	29.768	90.0	SSW	4	Lat. 9° 43' N, Long. 70° 13' E. Distance 270 miles.
	4 P.M.	29.808	90.0	S	4	Fresh breeze and fine with passing clouds. At 3 P.M., wind drawing to eastward.
	8 P.M.	29.818	90.0	Variable	4	Moderate breeze and cloudy.
	Midnight	29.798	90.0	SSW	4	Fresh breeze and fine weather.
<i>S. R. Morrow</i>	8 A.M.	...	...	S	...	
	8 A.M.	...	...	S	...	Moderate gale.
	9 A.M.	...	...	SSE	...	
	Noon	...	...	SSE	...	Lat. 17° 50' N, Long. 72° 3' E. Course S. 57° W. Distance 56 miles.
	4 P.M.	...	...	S by W	...	
	8 P.M.	...	...	S by W	...	Strong breeze with hard squalls and rain.
	9 P.M.	...	...	S	...	Ditto ditto.
	Midnight	...	...	S	...	Ditto ditto.

THE ARABIAN SEA CYCLONE OF

TABLE XIX.—10 A.M., 10th June 1887.

STATION.	Barometer.	Change in 24 hours.	Abnormal.	WIND.			Thermometer.	Relative humidity.	Cloud.	Rain-fall.	Remarks in the weather at 10 A.M.
				Direction.	VELOCITY.						
					At 10 A.M.	Mean of day.					
	"	"	"		Miles per hour.	Miles per hour.	°	Per cent.	0 to 10.	"	
Aden . . .	29'674	—'006	...	SE	...	9	89'6	68	0	Nil.	
Bushire . . .	'530	—'008	...	NW	...	...	89'8	73	?	Nil.	
Kurrachee . . .	'598	+ '031	—'039	SSE	9	14	90'0	61	1	Nil.	Fine weather with passing clouds.
Bhuj . . .	'593	+ '009	—'052	SSE	19	17	89'6	51	0	0'24	Blue sky.
Rajkot . . .	'596	+ '008	—'079	ESE	9	5	91'5	46	2	0'06	Cloudy.
Surat . . .	'662	+ '002	—'071	SW	F*	...	84'6	77	6	Nil.	Fine weather with passing clouds.
Bombay . . .	'728	+ '042	—'051	S	36	29	77'7	93	10	0'38	Overcast with rain.
Ratnagiri . . .	'784	+ '055	—'016	SE	8	11	79'3	87	10	1'86	Overcast.
Karwar . . .	'854	+ '065	+ '023	SW	F*	...	76'1	98	10	5'39	Heavy rain.
Mangalore . . .	'874	+ '025	+ '020	ESE	4	3	79'4	85	10	3'93	Overcast.
Calicut . . .	'874	+ '019	—'011	Calm	0	5	78'6	86	6	1'30	Fine weather with passing clouds.
Cochin . . .	'902	+ '025	+ '005	NE	L*	...	78'0	86	10	0'58	Overcast.
Colombo . . .	'891	+ '002	...	SSW	...	9	81'5	75	7	0'19	Fine.
Galle . . .	'887	+ '010	...	W	6	10	80'5	91	3	0'09	
Jacobabad . . .	'507	—'020	—'032	SSE	17	7	104'1	31	0	Nil.	Dust storm.
Hyderabad (Sind)	'597	+ '038	+ '028	SW	10	10	93'4	48	0	Nil.	Blue ky.
Neemuch . . .	'652	+ '016	+ '019	SW	...	...	83'6	68	2	Nil.	Cloudy.
Deesa . . .	'657	+ '018	—'006	S	18	16	88'5	55	9	Nil.	Drizzling rain.
Indore . . .	'654	+ '061	—'012	SW	7	6	83'7	60	5	0'28	Cloudy.
Akola . . .	'685	+ '014	—'002	NW	15	8	87'8	57	8	0'12	Ditto.
Malegaon . . .	'694	+ '026	—'003	SW	11	9	82'3	60	10	0'14	Overcast.
Poona . . .	'752	+ '011	—'014	SW	18	12	82'5	63	7	0'03	Cloudy.
Sholapur . . .	'765	+ '019	+ '007	WSW	12	11	83'4	58	9	Nil.	Ditto.
Belgaum . . .	'817	+ '071	—'007	SSW	23	27	68'8	95	10	0'77	Raining.
Bellary . . .	'817	+ '049	+ '030	W	...	12	82'9	58	10	Nil.	Overcast.
Bangalore . . .	'900	+ '022	+ '070	W	...	7	72'7	81	10	0'05	Overcast.
Salem . . .	'887	+ '080	+ '037	WNW	...	5	80'5	71	5	0'03	Very clear.

* For abbreviations see foot-note in page 419.

TABLE XX.—10th June 1887.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
S. S. Albany . . .	5 A.M.	...	...	NW	5	
	6 A.M.	29'268	83	NW	5	South-west sea decreasing.
	11 A.M.	29'226	84	NW	5	Ditto ditto.

THE 4TH TO 13TH JUNE 1887.

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TABLE XX.—10th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
S. S. Albany—contd.	Noon	29.146	84	N	6 to 7	Lat. 19° 49' N, Long. 66° 35' E. Course N. 48½° E. Distance 240 miles. Every cyclonic appearance. Increasing northerly sea.
	1 P.M.	29.146	84	N	6 to 7	Weather gradually worse. Sea inclined to N.E. rollers. Considered cyclone centre to be south-east of the vessel.
	2 P.M.	29.146	84	N	6 to 7	Ditto ditto.
	3 P.M.	29.129	83.5	N	6 to 7	Ditto ditto.
	4 P.M.	29.049	83	N	6 to 7	
	5 P.M.	29.050	83.7	N	6 to 7	Sea increasing at NNE.
	6 P.M.	29.036	84	N	6 to 7	Sea striking ship heavily under fore-foot and bottom forward.
	7 P.M.	29.031	82.5	N	6 to 7	Ditto ditto.
	8 P.M.	29.044	85	N	6 to 7	Lightning to the SE.
	9 P.M.	29.043	85.5	N by W	6 to 7	Ditto.
S. S. Azam	10 P.M.	29.042	86	N by W	6 to 7	Ditto.
	Midnight	29.024	85	N by W	6 to 7	Ditto.
	1 A.M.	...	...	SW by S	9	
	3 A.M.	...	...	SW by S	7	Moderate gale with high sea. Ship labouring heavily and shipping heavy quantities of water.
	4 A.M.	29.416	85.7	SW by S	7	
	6 A.M.	...	...	SW	7	
	8 A.M.	29.506	86.7	SW	7	Strong monsoon and cloudy. High SW sea. Ship labouring heavily and taking water over.
	10 A.M.	...	...	S by W	9	Ditto ditto.
	Noon	29.496	87.7	S by W	7	Ditto ditto.
	1 P.M.	...	...	SSW	7	Lat. 16° 10' N, Long. 64° 32' E. Course S. 75° W. Distance 104 miles.
S. S. Assyria	2 P.M.	...	...	SSW	7	Ship labouring heavily and shipping large quantities of water.
	4 P.M.	29.466	83.7	SSW	7	Strong gale with high confused sea. Shipping large quantities of water endangering life on deck.
	6 P.M.	29.496	85.7	SSW	7	Strong gale with high confused sea. Shipping heavy water.
	Midnight	29.486	86.7	SSW	8	Strong gale and furious squalls. Ship labouring heavily and shipping heavy water.
	4 A.M.	29.495	84.5	NNW	...	Light wind and fine weather. Smooth sea.
	4 P.M.	29.465	88.5	W	...	At Bushire. Strong wind and fine clear weather.
	8 P.M.	29.475	88.5	W	...	Moderate head breeze and fine weather.
	Midnight	29.475	86.5	W	...	Light head wind and clear weather.
	4 A.M.	...	...	SW	7	Fresh gale. Heavy SW sea. Shipping much water fore and aft. Rolling very heavily.
	4 P.M.	29.628	72.4	SW	7	Wind and sea increasing.
S. S. Britannia	5 A.M.	...	...	SW	8	Shipped a heavy sea.
	8 A.M.	29.598	73.4	SW	8	Hard gale with high cross broken sea and terrific squalls at times.
	Noon	29.668	73.4	SW	8	Lat. 12° 25' N, Long. 54° 55' E. Course N 43° W. Distance 182 miles. Strong gale with high beam sea.
	1 P.M.	...	...	SW	9	Hard gale and high sea.
	3 P.M.	...	...	SW	9	
	5 P.M.	...	...	SW	9	

THE ARABIAN SEA CYCLONE OF

TABLE XX.—10th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Britannia</i> —contd.	4 P.M.	...	70'4	SW	9	
	8 P.M.	29'628	70'4	SW	2	Heavy gale, sea moderating.
	10 P.M.	...	...	SW	7	Very heavy squalls.
	Midnight	29'658	70'4	SW	6	Wind and sea moderating.
<i>S. S. Canara</i>	1 A.M.	...	...	Variable	...	
	4 A.M.	29'727	83'6	Variable	...	At 3 A.M. strong head wind and heavy sea. Sky overcast. Ship labouring heavily.
	8 A.M.	29'742	81'6	Variable	...	Heavy rain squalls. High sea. Ship labouring heavily.
	Noon	29'757	81'6	Variable	...	Lat. 17° 21' N. Long. 72° 3' E. Course various. Distance 96 miles. Dull cloudy weather.
	1 P.M.	...	...	SW	...	
	4 P.M.	29'727	80'6	SW	...	Strong wind and high sea. Ship labouring heavily.
	6 P.M.	...	...	Variable	...	
	8 P.M.	29'757	78'6	Variable	...	Dark cloudy weather. Ship labouring and rolling heavily.
	Midnight	29'767	78'6	Variable	...	Heavy rain squalls and south-west swell. Ship pitching and rolling heavily.
	1 A.M.	...	...	W	...	
<i>S. S. Chanda</i>	4 A.M.	29'703	80'0	WSW	...	Moderate wind with heavy rain. Weather cloudy and overcast. High WSW sea. Ship rolling very heavily at times.
	4-30 A.M.	...	...	...	...	Heavy squall of wind and rain.
	5 A.M.	...	...	SW	...	Moderate wind and heavy rain with high sea.
	8 A.M.	29'703	80'0	Variable	...	Ship lurching very heavily.
	11 A.M.	...	...	SW	...	
	Noon	29'703	80'0	SW	...	Lat. 17° 29' N. Long. 72° 50' E. Course various. Distance 133 miles. Moderate wind and heavy squalls. High sea. Ship lurching heavily at times.
	1 P.M.	...	...	SW to WSW	...	
	4 P.M.	29'703	81'0	...	...	Light breeze with continuous rain. Heavy swell from westward. Ship lurching heavily.
	8 P.M.	29'703	82'0	...	...	Moderate breeze. Heavy beam swell. Ship lurching heavily. Weather clear.
	Midnight	29'723	90'0	...	...	At Bombay. Light breeze. Sky overcast.
<i>S. S. Clan Forbes</i>	1 A.M.	...	...	SW	...	Decreasing gale. Sea still very high. Ship labouring and rolling very heavily.
	4 A.M.	29'452	79'5	SW	...	Strong gale. High mountainous sea. Decks flooded.
	8 A.M.	29'482	83'5	SW	...	Wind and sea moderating. Clear horizon.
	9 A.M.	...	...	SW	...	Hazy overhead.
	10 A.M.	...	...	SW	...	Wind and sea moderating. Barometer steadily rising.
	Noon	29'532	87'5	SW	...	Lat. 16° 36' N. Long. 66° 0' E. Course N 64° E. Distance 59 miles. Wind and sea moderating.
	1 P.M.	...	...	SW	...	Strong decreasing gale. Passing clouds. High following sea.
	4 P.M.	29'532	89'5	SW	...	Strong gale. High following sea. Hazy. Overcast.
	8 P.M.	29'592	86'5	SW	...	Strong gale. Following sea. Weather clear and overcast alternately.
	Midnight	29'622	83'5	SW	...	Moderate gale. High sea. Weather clear.
<i>S. S. Clan Graham</i>	1 A.M.	...	...	WSW	...	Strong gale with fierce squalls from south-westward. Weather gloomy. Less swell and sea

TABLE XX.—10th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Clan Graham</i> — contd.	4 A.M.	29.488	87.8	...	...	Weather same. Ship labouring heavily and shipping much water fore and aft. Hard unsteady gale with high sea. Vessel labouring very heavily and shipping much water.
	6 A.M.	...	...	...	...	
	8 A.M.	29.511	86.8	Variable	...	
	10 A.M.	...	...	W	...	Lat. 16° 58' N, Long. 58° 20' E. Course S 72° W. Distance 110 miles. Strong unsteady gale with dull gloomy weather. High sea running. Ship labouring heavily and shipping heavy water fore and aft.
	Noon	29.511	86.8	...	...	
	1 P.M.	...	...	WSW to NW	...	
	4 P.M.	29.491	86.8	Variable	...	
	5 P.M.	...	...	Variable	...	
	8 P.M.	29.513	85.8	WSW	...	
	Midnight	...	...	...	...	
<i>S. S. Clan Matheson</i>	4 A.M.	29.737	83.0	SW by S	7	Appearances improved.
	8 A.M.	29.787	83.0	SW by S	6	Moderating still.
	Noon	29.797	83.0	SW	6	Lat. 10° 28' N, Long. 68° 09' E. Squally with rain and high sea.
	4 P.M.	29.805	84.0	SW	5	Wind and sea continue to moderate. Moderate monsoon. Squally with rain. Sea moderate. At Bombay. Strong wind and rain at times.
	8 P.M.	29.827	83.0	SW	5	
	Midnight	29.860	82.0	SW	5	
<i>S. S. Commilla</i>	8 A.M.	29.576	82.5	S	...	Strong wind and heavy SW sea. Strong wind and drizzling rain. Wind moderating.
	4 P.M.	29.586	81.5	SW	...	
	8 P.M.	29.596	81.5	SW	...	
	10 P.M.	...	...	SW	...	Weather same. Ship rolling heavily and shipping water fore and aft. Begins with hurricane. Heavy lightning and heavy sea. Barometer rising. Barometer falling. The hurricane at its height.
	Midnight	29.616	81.5	SW	...	
<i>S. S. Darien</i>	1 A.M.	...	...	SW	...	Hurricane abating. Shipped a sea over upper bridge. Lat. 17° 16' N, Long. 62° 40' E. Course ENE. Distance 250 miles. Moderate wind.
	2 A.M.	...	...	SW	...	
	3 A.M.	...	...	SW	...	
	8 A.M.	...	...	SW	...	Fresh breeze and squally with heavy rain at times and high SW sea. Ship labouring and straining and shipping large quantities of water on board fore and aft.
	14 A.M.	...	...	SW	...	
	Noon	...	90.0	SW	...	
	8 P.M.	...	...	SSW	...	
<i>S. S. Eden Hall</i>	Midnight	...	90.0	...	...	Ditto ditto. Ditto ditto. Ditto ditto. Ditto ditto. Ditto ditto.
	1 A.M.	...	...	SW	...	
	2 A.M.	29.503	83.6	SW	...	
	4 A.M.	29.533	83.6	SW	...	
	6 A.M.	29.503	81.6	...	...	
	7 A.M.	...	...	WSW	...	
	8 A.M.	29.533	79.6	WSW	...	

THE ARABIAN SEA CYCLONE OF

TABLE XX.—10th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Eden Hall</i> —contd.	10 A.M.	29.533	83.6	WSW	...	
	Noon	29.533	83.6	WSW	...	Lat. 17° 59' N, Long. 68° 9' E. Course S 78° W. Distance 228 miles. Fresh breeze and cloudy with high head sea. Ship taking large quantities of water on board over the bows.
	1 P.M.	...	...	SW	...	Fresh wind and overcast sky with misty rain and high head sea. Ship labouring heavily and shipping large quantities of water on board fore and aft.
	2 P.M.	29.533	82.6	SW	...	
	4 P.M.	29.503	82.6	SW	...	
	6 P.M.	29.533	82.6	SW	...	Strong breeze and squally with heavy rain. Ship pitching and labouring, filling decks with water.
	8 P.M.	29.553	82.6	SW	...	
	10 P.M.	29.533	83.6	...	...	
	Midnight	29.533	83.6	...	...	Fresh breeze and squally with rain at times and high head sea.
<i>S. S. Etolia</i>	3 A.M.	...	...	W to S	...	Strong breeze and squally. Heavy sea running. Shipping heavy seas over the bows filling the decks fore and aft.
	6 A.M.	...	...	W to S	...	Strong breeze. Heavy rain squalls. Very heavy cross sea.
	7 A.M.	...	...	W	...	
	Noon	29.697	...	W	...	Lat. 16° 23' N, Long. 68° 44' E. Course S. 79° W. Distance 150 miles. Moderate to light wind and very heavy sea.
	1 P.M.	...	...	S to SW and W	...	
	4 P.M.	...	...	S to SW and W	...	Strong breeze and squally with heavy sea running. Shipping large quantities of water over all.
	6 P.M.	...	...	Variable	...	Same weather.
	8 P.M.	...	...	Variable	...	Same weather. Wind varying from S to W N W.
	Midnight	...	...	...	...	Hard squalls. Heavy rain. Very high confused sea. Decks flooded.
<i>S. S. Europa</i>	1 A.M.	...	...	S	...	Fresh breeze and heavy rain squalls. High cross sea. Decks flooded fore and aft. Ship pitching heavily.
	Noon	...	...	S	...	Ditto ditto.
	1 P.M.	...	...	S	...	Lat. 16° 1' N, Long. 70° 25' E. Course W ½ N. Distance 134 miles.
						Up to midnight fresh breeze and high confused sea. Ship rolling and pitching heavily. Decks flooded.
<i>S. S. Germania</i>	1 A.M.	...	...	...	...	Light wind and clear weather.
	2 A.M.	...	...	SW	...	
	4 A.M.	...	...	...	...	Moderate wind and clear weather.
	Noon	...	...	...	...	Ditto ditto.
	2 P.M.	...	...	WSW	...	Lat. 13° 14' N, Long. 50° 35' E. Course N 70° E. Distance 228 miles.
	4 P.M.	...	...	WSW	...	Moderate breeze and clear weather.
	8 P.M.	...	...	WSW	...	Fresh breeze and strong cross sea.
	Midnight	...	...	WSW	...	Ditto ditto.
<i>S. S. Giava</i>	1 A.M.	29.700	78.8	SSE	...	
	5 A.M.	29.700	80.6	SSE	4	

TABLE XX.—10th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Giava</i> —contd.	9 A.M.	29.700	80.6	SSE	4	
	Noon	...	...	...	...	Lat. 18° 26' N, Long. 72° 28' E. Course N 75° E. Distance 243 miles.
<i>S. S. Henry Belkew</i>	1 A.M.	...	...	S	...	
	8 A.M.	29.523	82.5	S	...	
	3 P.M.	...	...	S	...	At Karachi.
	4 P.M.	29.603	91.5	...	...	Moderate breeze and fine weather with moderate head sea.
	8 P.M.	29.583	82.5	...	...	Moderate wind and clear weather. Heavy sea from south.
	Midnight	29.603	84.5	SW	...	Light breeze and fine weather. Heavy swell from southward.
<i>S. S. Hydaspes</i>	1 A.M.	...	...	SW	7	
	4 A.M.	29.635	79.9	SSW	7	Moderate monsoon gale and high sea. Ship pitching and rolling very heavily and taking large quantities of water.
	8 A.M.	29.734	79.9	SSW	7	Strong monsoon and hazy weather. Ship pitching very heavily and rolling at times and taking large quantities of water on board.
	Noon	29.682	80.9	SSW	7	Lat. 21° 8' N, Long. 59° 41' E. Course N 65° W. Distance 186 miles. Strong monsoon and hazy. High beam sea. Ship lurching heavily and shipping much water.
	4 P.M.	29.684	79.9	SSW	7 to 8	Fresh monsoon gale and squally. Ship labouring heavily to a high sea and shipping water.
	8 P.M.	29.629	81.9	SSW	7 to 8	Strong monsoon gale and squally. Ship labouring heavily to a high sea and shipping much water.
	Midnight	29.640	77.9	SSW	7 to 8	Strong monsoon gale with furious squalls. Ship labouring heavily and shipping large quantities of water.
<i>S. S. Java</i>	1 A.M.	...	...	E	...	
	4 A.M.	29.567	88.1	...	...	Moderate breeze with high monsoon swell. Ship rolling considerably.
	8 A.M.	29.627	84.1	...	...	Ditto ditto.
	Noon	29.597	86.1	...	...	Lat. 24° 45' N, Long. 66° 46' E. Course S 87° E. Distance 190 miles.
	4 P.M.	...	...	...	...	Light wind and fine weather.
<i>S. S. Juma</i>	4 A.M.	29.633	74.0	SW	9	Strong gale and high sea.
	4.30 to 7.30 A.M.	...	...	SW	...	Blowing a very hard gale with squalls of terrific violence.
	8 A.M.	29.633	74.0	SW	10	At 10 A.M. wind and sea increasing.
	Noon	29.640	76.0	SW	8	Lat. 13° 3' N, Long. 54° 13' E. Distance 192 miles. Moderate gale with increasing sea.
	4 P.M.	29.543	75.0	SW	6	Weather moderating.
	Midnight	...	...	SW	9	Strong increasing gale with rising sea.
<i>S. S. Kangra</i>	6 A.M.	...	...	SE	3	
	8 A.M.	29.536	84.8	SE	3	
	Noon	29.579	83.8	SE	3	At Karachi.
	3 P.M.	...	...	SE	3	
	4 P.M.	29.611	86.8	NE	2	
	8 P.M.	29.561	86.8	NE	2	
	Midnight	...	...	NE	2	

THE ARABIAN SEA CYCLONE OF

TABLE XX.—10th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Kohinur</i>	1 A.M.	...	...	SW	4	
	8 A.M.	...	...	SW	3	Moderate sea and fine weather. Ship rolling to SW swell.
	Noon	...	...	SW	3	Lat. $4^{\circ} 31' N$, Long. $79^{\circ} 19' E$. Course various. Distance 100 miles. Gentle breeze and fine clear weather.
	1 P.M.	...	...	SW	2	
	6 P.M.	...	...	SW	3	
<i>S. Lorna Doone</i>	2 A.M.	...	...	NE	12	Hurricane blowing fiercely with squalls. Sea very heavy and confused. Decks flooded with water fore and aft.
	4 A.M.	...	...	SSE to S	12	Gale blew with hurricane force till 5.30 A.M. when barometer began to rise.
	5.30 A.M.	...	...	SSE to S	...	Fresh gale.
	Noon	29.320	...	...	...	Lat. $19^{\circ} 52' N$, Long. $63^{\circ} 53' E$. Moderate gale.
<i>S. S. Merton Hall</i>	Noon	29.642	86.0	...	...	Lat. $12^{\circ} 22' N$, Long. $43^{\circ} 59' E$. Course various. Distance 257 miles.
	2 P.M.	...	...	Variable	...	Light variable airs with close muggy appearance.
	9 P.M.	...	...	SW	...	
	Midnight	...	...	...	...	Moderate breeze and overcast.
<i>S. R. Morrow</i>	1 A.M.	...	...	S	...	
	8 A.M.	...	...	S	...	Heavy rain.
	Noon	...	...	S	...	Lat. $47^{\circ} 26' N$, Long. $71^{\circ} 0' E$. Course S by W. Distance 25 miles.
	1 P.M.	...	...	SSW	...	Moderate gale with high sea and hard squalls.
	Midnight	...	...	SSW	...	Rain.
<i>S. S. Navarino</i>	4 A.M.	29.798	90.0	SSW	3	At 3 A.M. heavy south-westerly squall with rain and thick weather.
	8 A.M.	29.858	88.0	SSW	3	Moderate wind with heavy rain.
	Noon	29.828	88.0	SSW	3	Lat. $8^{\circ} 27' N$, Long. $73^{\circ} 57' E$. Distance 234 miles. Light breeze and fine but cloudy.
	4 P.M.	29.788	86.0	Variable	2	Light breeze and cloudy.
	8 P.M.	29.848	88.0	Variable	1	Light airs and overcast sky.
	Midnight	29.808	88.0	Variable	1	Light airs and clear.
<i>S. S. Nizam</i>	1 A.M.	...	...	SW	6	Moderate increasing monsoon and cloudy.
	3 A.M.	...	...	SW	6	Wind and sea increasing.
	4 A.M.	...	71.3	SW	6	Moderate monsoon gale with very heavy following sea. Ship rolling heavily and shipping water over all at times.
	6 A.M.	...	...	SW	6	Wind and sea increasing, overcast and raining.
	8 A.M.	...	79.3	SW	8	Fresh monsoon gale with high sea. Ship rolling and lurching heavily at times and taking water over amid-ship. Weather overcast with light rain.
	10 A.M.	...	...	SW	8	Wind and sea rapidly increasing.
	12 A.M.	...	79.3	SW	9	
	Noon	...	81.3	SW	9	Lat. $16^{\circ} 6' N$, Long. $59^{\circ} 19' E$. Strong gale with furious squalls. Vivid lightning and thunder and heavy rain with fast falling barometer and indications of a cyclone. Ship pitching and labouring very heavily and shipping great quantities of water.

THE 4TH TO 13TH JUNE 1887.

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TABLE XX.—10th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Nizam</i> —contd.	1 P.M.	...	...	SW	8	Heavy gale with very high sea. Ship labouring and lurching heavily and shipping much water at times.
	2 P.M.	...	...	SW	8	Ditto ditto.
	3 P.M.	...	...	SW	9	Ditto ditto.
	4 P.M.	...	79°3	SW	9	Heavy gale with very high sea. Ship labouring and lurching heavily and shipping much water at times.
	6 P.M.	...	80°3	SW	9	Ditto ditto.
	8 P.M.	...	80°3	SW	9	Hard gale with terrific sea running. Ship labouring heavily and shipping quantities of water fore and aft.
	11 P.M.	...	...	SW	9	Hard gale with furious squalls. Very high sea running.
	Midnight	...	79°3	SW	9	Ship labouring and lurching heavily and shipping much water.
<i>S. S. Nurjahan</i>	1 A.M.	...	...	N	1	At Aleppi. Heavy westerly swell.
	Midnight	29°847	79°5	Variable	...	Light variable airs and cloudy.
<i>S. S. Oswald</i>	1 A.M.	...	...	SW by W	...	Fresh gale and high sea with furious squalls.
	4 A.M.	...	81°1	...	...	Wind and sea moderating.
	5 A.M.	...	...	WSW	...	
	8 A.M.	...	82°1	WSW	...	Strong wind and squally with high sea.
	Noon	...	83°1	WSW	...	Lat. 16° 32' N, Long. 67° 19' E. Course S 84° E. Distance 145 miles.
	4 P.M.	...	83°7	WSW	...	
	6 P.M.	...	...	WSW	...	Strong wind and heavy sea.
	9 P.M.	...	83°1	SW	...	At 8 P.M., wind moderating. Heavy sea still running.
<i>S. S. Pachumba</i>	Midnight	...	82°1	SW	...	Fresh breeze and cloudy.
	1 A.M.	...	...	S	...	
	4 A.M.	29°610	85°5	...	...	Fresh wind and heavy swell with overcast sky.
	5 A.M.	...	...	SSE	...	
	8 A.M.	29°610	83°5	...	...	Fresh head breeze and cloudy with heavy confused sea. Ship rolling and pitching heavily.
	Noon	29°610	85°5	...	...	Ditto ditto. Lat. 22° 54' N, Long. 68° 0' E. Course various. Distance 139 miles.
	1 P.M.	...	...	SSE	...	
	4 P.M.	29°610	83°5	...	...	Moderate wind and heavy confused sea.
<i>S. S. Persia</i>	6 P.M.	...	...	SSW	...	
	8 P.M.	29°620	83°5	...	...	Strong breeze and dark cloudy weather with heavy confused sea. Ship rolling and pitching heavily.
	Midnight	29°630	83°5	...	...	Ditto ditto with rain.
	1 A.M.	29°652	90°1	Variable	1 to 2	Light variable winds and hazy.
	3 A.M.	29°652	89°1	...	...	At 4 A.M. light southerly wind and overcast.
	5 A.M.	29°652	88°1	S	2	
	7 A.M.	29°672	87°1	...	...	
	8 A.M.	...	...	SSW	4	Fresh breeze and hazy.

THE ARABIAN SEA CYCLONE OF

TABLE XX.—10th June 1887—continued.

NAME OF VESSEL.	HOUR.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Persia</i> —contd.	9 A.M.	29.672	85.1	SSW	4	Fresh breeze and hazy.
	11 A.M.	29.672	87.4	SSW	4	Ditto ditto.
	Noon	...	...	SSW	4	Ditto ditto.
	1 P.M.	29.652	90.1	SSW	4	Lat. 13° 40' N, Long. 51° 56' E. Course N 81½ E. Distance 270 miles.
	3 P.M.	29.652	88.1	SSW	4	
	4 P.M.	...	...	SSW	4	Strong breeze and heavy beam sea.
	5 P.M.	29.622	87.1	SSW	4	
	6 P.M.	...	...	SSW	5	
	7 P.M.	29.602	85.1	SSW	5	
	8 P.M.	...	...	SSW	5	Strong breeze. Shipping large quantities of water fore and aft. Vessel straining heavily.
	9 P.M.	29.592	84.1	SSW	5	Ditto ditto.
<i>S. S. Purulia</i>	11 P.M.	29.572	83.1	SSW	5	Ditto ditto.
	Midnight	...	...	SW	6 to 7	Ditto ditto.
	4 A.M.	...	...	NW	...	Fine weather.
	8 A.M.	...	...	NW	...	Light breeze and fine.
	Noon	...	...	NW	...	At Bushire. Light breeze and fine.
	4 P.M.	...	...	...	...	Fine and clear.
<i>S. S. Rockcliff</i>	8 P.M.	...	93.0	Variable	...	Light variable wind, fine and hazy.
	Midnight	29.509	88.0	NW	...	Light airs and fine. Thick and hazy during first half of watch.
	1 A.M.	...	...	SW	...	Storm continues unabated. Steamer labouring heavily and shipping large quantities of water.
	4 A.M.	...	...	SW	...	Weather moderating.
	Noon	...	...	SW	...	Lat. 17° 34' N, Long. 66° 38' E. Course N 81° E. Distance 224 miles.
<i>S. S. Rothsay</i>	1 P.M.	...	...	SSW	...	Fresh wind and cloudy. Sea continues heavy.
	Midnight	...	...	SSW	...	
	4 A.M.	...	...	SSW	...	
	4 A.M.	...	...	SSW	...	Fresh gale with heavy following seas. Shipping quantities of water.
	8 A.M.	...	...	SSW	...	Ditto ditto.
	Noon	29.523	...	SSW	...	Lat. 44° 30' N, Long. 58° 13' E. Course N 26° E. Distance 180 miles.
	4 P.M.	...	...	SSW	...	Heavy gale with tremendous sea. Weather misty.
	5 P.M.	...	...	SW	...	
	6 P.M.	...	...	SW	...	Mountainous sea running with terrific squalls.
	8 P.M.	...	...	SW	...	Gale increasing in force. Rain squalls.
<i>S. S. Satara</i>	10 A.M.	...	...	SSW	...	Lightning to NE.
	Midnight	...	...	SSW	...	Violent squalls. Weather very threatening.
	1 A.M.	...	...	S	...	

TABLE XX.—10th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	WIND.		REMARKS.
				Direction.	Force.	
S. S. Salara—contd.	3 A.M.	...	...	N	...	
	4 A.M.	...	86.3	N	...	Light breeze and cloudy. Heavy weather. Southerly swell.
	6 A.M.	...	...	NNE	...	
	8 A.M.	...	88.3	NNE	...	Light breeze and fine weather. Heavy swell from southward.
	10 A.M.	...	...	SE	...	
	Noon	...	89.3	SE	...	Lat. 24° 48' N. Long. 63° 56' E. Course N 89° W. Distance 165 miles.
	4 P.M.	29.535	86.3	SE	...	Moderate following wind. Heavy SE swell. Moderate following breeze and fine weather. Heavy south-easterly swell.
	8 P.M.	29.562	87.3	SE	...	Moderate breeze and fine weather. Heavy southerly swell.
	10 P.M.	...	...	S	...	
	Midnight	...	86.3	S	...	Less wind and squally appearance.
S. S. Sumatra	1 A.M.	...	...	SSW	...	
	2 A.M.	...	...	SSW	...	At 3-10 A.M. a tremendous sea struck ship forward.
	4 A.M.	...	...	SSW	...	Strong wind and very high cross sea.
	6 A.M.	...	...	SSW	...	
	8 A.M.	...	...	SSW	...	Strong breeze. Heavy squalls. Ship labouring and shipping large quantities of water.
	Noon	...	...	SSW	...	Strong breeze. Heavy squalls. Ship labouring and shipping large quantities of water.
	2 P.M.	...	...	SSW	...	Lat. 18° 43' N. Long. 64° 28' E. Course S 69° W. Distance 94 miles.
	4 P.M.	...	...	SSW	...	Strong breeze and heavy squalls. Ship labouring heavily and shipping water fore and aft.
	6 P.M.	...	...	SSW	...	
	8 P.M.	...	...	SSW	...	Same weather. Ship pitching and taking much water over all.
S. S. Swordsman	10 P.M.	...	...	SSW	...	
	Midnight	...	...	SSW	...	Strong breeze and fine with tremendously high sea. Ship labouring heavily and shipping much water.
S. S. Barpeia	1 P.M.	...	...	SW	...	Near Zanzibar.
	6 P.M.	...	...	SW	...	Strong wind. Hazy. Moderate sea.
S. S. Victoria	1 A.M.	...	...	SW	...	Fresh breeze and clear weather.
	6 A.M.	...	...	SW	...	Ditto ditto.
	Noon	...	...	SW	...	Lat. 12° 30' N. Long. 49° 42' E. Course N 83° E. Distance 183 miles.
	1 P.M.	...	...	...	...	Fresh breeze and clear weather.
	5 P.M.	...	...	SW	...	Fresh variable winds with short high sea and hazy weather.
	8 P.M.	...	...	...	...	Strong breeze with high sea and hazy weather.
	10 P.M.	...	...	S	...	
S. S. Victoria	3 A.M.	...	...	WSW	...	Wind increasing.
	5 A.M.	...	...	...	...	Blowing a moderate gale with a short choppy sea and overcast sky.
	10-20 A.M.	...	...	...	...	Fresh gale and very heavy confused sea. Shipping large quantities of water fore and aft.
	Noon	...	...	...	...	Lat. 16° 5' N. Long. 57° 25' E. Course S 75° W. Distance 120 miles.
	8 P.M.	...	...	...	...	Similar weather with wind unsteady in force.

THE ARABIAN SEA CYCLONE OF

TABLE XX.—10th June 1887—concluded.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Wivehoe</i>	I A.M.	...	...	...	...	Light wind and hazy weather.
	7 A.M.	...	...	SW	...	
	8 A.M.	...	...	SW	...	Fresh wind and hazy weather.
	Noon	...	...	SW	...	Near Aden ditto.
	Midnight	...	...	SW	...	Beam sea. Ship rolling. Same weather.

TABLE XXI.—10 A.M., 11th June 1887.

STATION.	Barometer.	Change in twenty- four hours.	Abnormal.	WIND.			Ther- mome- ter.	Relative humid- ity.	Cloud.	Rain- fall.	Remarks on the weather at 10 A.M.
				Direction.	VELOCITY.						
					At 10 A.M.	Mean of day.					
					Miles per hour.	Miles per hour. 10	o	Per cent.	o to 10		
Aden . .	29.662	—012	...	S	...	...	90.4	74	0	Nil.	
Bushire . .	502	—028	...	NW	...	...	88.8	77	?	Nil.	
Kurrachee . .	583	—015	—049	SW	15	15	90.0	63	3	Nil.	Fine weather with passing clouds.
Bhuj . .	625	+032	—017	SSE	17	12	84.2	70	4	0.56	Cloudy.
Rajkot . .	643	+047	—028	SSW	10	5	88.5	54	6	Nil.	Ditto.
Surat . .	719	+057	—011	WSW	M*	...	87.6	80	9	0.61	Dark gloomy weather.
Bombay . .	797	+069	+021	NNW	12	20	74.4	94	10	1.61	
Ratnagiri . .	797	+013	—001	SSW	10	7	71.8	93	10	2.21	Overcast with rain.
Karwar . .	847	—007	+017	SW	P*	...	74.1	95	10	2.87	Drizzling rain.
Mangalore . .	884	+010	+030	ENE	4	3	72.5	95	10	5.03	Heavy rain.
Calicut . .	887	+013	+002	NNW	5	5	74.6	89	10	1.25	Drizzling rain.
Cochin . .	911	+009	+013	N	L*	...	74.0	93	10	0.92	Ditto.
Colombo . .	857	—034	...	SW	...	8	81.0	74	10	0.14	Overcast.
Galle . .	854	—033	...	...	...	...	...	...	...	Nil.	
Jacobabad . .	488	—019	—046	SSW	18	7	101.3	37	2	Nil.	Cloudy.
Hyderabad (Sind)	569	—028	+005	SW	12	11	94.0	37	2	Nil.	Ditto.
Neemuch . .	643	—009	+013	WSW	...	...	81.6	72	7	Nil.	Ditto.
Deesa . .	676	+019	+016	SSE	18	17	89.2	50	10	Nil.	Overcast.
Indore . .	636	—018	—028	W	12	6	82.7	63	6	0.06	Cloudy.
Akola . .	714	+029	+030	NW	3	11	84.9	60	9	0.10	Ditto.
Malegaon . .	710	+016	+015	SSW	17	10	81.8	64	10	0.36	Overcast.
Poona . .	795	+043	+030	W	23	19	77.7	78	10	0.15	Ditto.
Sholapur . .	709	—056	—049	NNW	18	13	84.7	53	8	Nil.	Cloudy.
Belgaum . .	781	—036	—043	WSW	31	25	72.8	86	10	0.70	Strong wind.
Bellary . .	771	—046	—015	W	...	16	82.9	53	8	Nil.	Ditto.
Bangalore . .	887	—013	+056	W	...	8	69.7	80	10	0.29	Overcast.
Salem . .	866	—021	+016	SW	...	3	76.5	82	9	0.11	Very clear.

* For abbreviations see foot-note in page 419.

TABLE XXII.—11th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Albany</i>	4 A.M.	28.844	85.0	N	7	Murky since midnight. Wind gradually increasing in squalls.
	5 A.M.	28.824	85.0	...	...	
	6 A.M.	28.744	85.0	N	...	Strong gale.
	7 A.M.	28.818	83.5	...	...	Squally with hail and lightning scud from NE.
	8 A.M.	28.688	83.0	...	...	Very hazy and overcast. Scud from NEN and SW.
	9 A.M.	28.715	84.0	...	...	Gradual decrease of northerly sea and NE rollers.
	11 A.M.	28.723	85.0	...	...	Wind and sea decreasing. SW swell increasing. Haze clearing. Clouds still.
	Noon	28.793	85.0	S	12	Lat. 19° 4' N, Long. 60° 25' E. Course S 12° W. Distance 46 miles.
						Wind burst out with hurricane force with violent squalls and heavy seas. Heavy SW rollers. Dead calm for about 15 minutes during which numerous birds and insects flew about the ship.
	1 P.M.	28.848	83.5	S	12	Wind blowing a hurricane with violent squalls and heavy seas.
	2 P.M.	28.862	82.0	S	12	Ditto ditto.
	3 P.M.	28.858	80.0	S	12	Ditto ditto.
	4 P.M.	28.959	80.0	...	...	
	5 P.M.	29.020	79.7	SE	...	Clearing up rapidly. Less wind and sea. Wind gradually hauling to SE.
<i>S. S. Azam</i>	6 P.M.	29.130	79.0	...	...	Fresh breeze.
	7 P.M.	29.191	78.5	S to SE	...	Fine clear cloudless weather. Sheet lightning to SE.
	8 P.M.	29.234	81.0	...	...	Fresh to moderate wind. Very heavy swell from S.
	9 P.M.	29.291	82.0	...	...	Ditto ditto.
	3 A.M.	...	...	SW by S	7	Fresh gale with high sea. Ship labouring and shipping water fore and aft.
<i>S. S. Azam</i>	4 A.M.	29.436	...	SW by S	7	
	8 A.M.	29.366	87.7	SW by S	7	Strong monsoon gale. Very high sea. Ship labouring and shipping water fore and aft.
	9 A.M.	...	...	SSW	8	Ditto ditto.
	Noon	29.486	85.7	SSW	8	Ditto ditto.
						Lat. 17° 10' N, Long. 62° 30' E. Course S 64° W. Distance 131 miles.
	1 P.M.	...	...	SW by S	...	
	4 P.M.	29.446	86.7	SW by S	7	At 3 P.M. shipped heavy sea. At 4 P.M. strong monsoon gale. Ship labouring and shipping water fore and aft.
	8 P.M.	29.486	84.7	SW by S	7	Wind and sea slightly moderating.
	Midnight	29.486	87.7	SW by S	7	Moderate gale with slightly decreasing sea. Ship labouring heavily and occasionally shipping heavy water.
						Light wind and smooth sea with fine weather.
<i>S. S. Assyria</i>	4 A.M.	29.475	80.5	Variable	...	
	8 A.M.	29.465	85.5	...	...	Moderate breeze and fine weather.
	Noon	29.475	102.5	W	...	Strong warm westerly wind.
	2-10 P.M.	...	...	...	...	At Busserah.
<i>S. S. Bedewin</i>	1 A.M.	...	...	Variable	2	Light air, hazy weather and smooth sea.
	4 A.M.	29.733	83.4	Variable	2	Ditto ditto.
	8 A.M.	29.733	89.4	Variable	2	Ditto ditto.

THE ARABIAN SEA CYCLONE OF

TABLE XXII.—11th June 1887—continued.

NAME OF VESSEL.	HOUR.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Bedouin</i> —contd.	Noon	29'733	96'4	Variable	2	Lat. 12° 20' N, Long. 44° 45' E. Course various. Distance 211 miles. Light breeze and clear weather. Swell from SE.
	3 P.M.	...	...	SSE	...	
	4 P.M.	29'733	96'4	SSE	4	Breeze freshening.
	8 P.M.	29'653	94'4	Variable	2	Light unsteady wind and heavy SE swell.
	Midnight	29'613	92'4	Variable	2	Light variable breeze and fine weather.
<i>S. S. Britannia</i>	1 A.M.	...	...	WSW	6	Moderate gale with broken sea.
	4 A.M.	...	72'4	WSW	7	Wind and sea increasing.
	6 A.M.	...	...	SW	8	Hard gale with tremendous sea. Ship labouring very heavily. Decks continually awash.
	8 A.M.	29'658	72'4	SW	8	Ditto ditto with frightful seas running.
	Noon	29'648	68'4	SW	8	Lat. 12° 10' N, Long. 54° 35' E. Hard gale, with tremendous sea. Ship labouring very heavily. Decks continually awash, with frightful seas running. Weather continued bad. Kept away for east end of Socotra to get lee.
	4 P.M.	29'588	75'4	SW	8	
	8 P.M.	29'558	74'4	SW	8	Strong gale, with heavy squalls. Rolling heavily, and shipping water.
	Midnight	29'518	75'4	SW	8	At 11-30 P.M. strong gale, with frightful squalls of hurricane force.
<i>S. S. Canara</i>	4 A.M.	29'727	79'6	Variable	...	Light wind, and dull cloudy weather. Heavy swell. Ship labouring.
	8 A.M.	29'787	80'6	Variable	...	Squally weather. Sky overcast. Heavy swell. Ship rolling heavily.
	Noon	29'767	81'6	Variable	...	At Mormagoa. Light rain.
	2 P.M.	...	...	...	...	Frequent heavy showers.
	8 P.M.	29'767	80'6	...	...	Moderate breeze. Dull weather.
	Midnight	29'787	79'6	...	...	Ditto ditto.
	4 A.M.	29'683	82'0	S	...	At Bombay.
<i>S. S. Clan Forbes</i>	1 A.M.	...	...	SW	...	Moderate gale, and clear. Heavy sea. Shipping water.
	4 A.M.	29'582	83'5	SW	...	Strong wind. Cloudy. Less sea.
	8 A.M.	29'602	83'5	SW	...	Fresh wind. High following sea, partially overcast.
	Noon	29'632	86'5	SW	...	Lat. 17° 33' N, Long. 69° 38' E. Course N 77° E. Distance 216 miles. Wind and sea moderate. Weather clear.
	4 P.M.	29'682	89'5	SW	...	Moderate wind and clear weather.
	8 P.M.	29'652	87'5	SW	...	Fresh wind. Following sea. Overcast sky.
	9 P.M.	...	...	NW	...	At 8-30 P.M. squall from NW. Light rain.
	10 P.M.	...	...	Variable	...	
<i>S. S. Clan Graham</i>	Midnight	29'652	85'5	Variable	...	Light rain.
	1 A.M.	...	...	...	...	Strong gale and squally with rain throughout. High sea. Ship labouring heavily and shipping much water.
	4 A.M.	29'471	86'8	...	...	
	8 A.M.	29'414	85'8	...	...	Terrific gale with tremendous seas breaking over ship, and doing much damage on deck. Dull heavy overcast sky, with heavy rain.

TABLE XXII.—11th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Clan Graham</i> — contd.	9 A.M.	...	...	...	...	Rapid shifts of wind in all directions raising pyramids of sea tremendously high. Squalls accompanied by torrents of rain. Dull slaty sky. Vivid lightning and thunder. Decks flooded with water.
	Noon	...	...	...	...	Ditto ditto.
	1 P.M.	...	...	NW	...	Lat. 16° 55' N, Long. 57° 40' E. Course S 62° W. Distance 33 miles. From 10 A.M. to 3 P.M. ship in centre of cyclone. (?) At 3 P.M. strong gale set in from NW, veering in a few hours to W and WSW quarter. Dull, slaty sky.
	6 P.M.	...	...	W	...	Fierce gale with a fearful sea running, breaking on board fore and aft on both sides, filling decks with water. Ship straining. Deck working a great deal.
	8 P.M.	...	...	WSW	...	Wind direction WSW, up to midnight. Weather and wind same as at 6 P.M.
<i>S. S. Clan Matheson</i>	4 A.M.	29.827	83.0	SW	5	Moderate and clear. Heavy passing rain squalls. Lightning all over.
	8 A.M.	29.837	83.0	SW	5	Ditto ditto.
	Noon	29.760	82.0	SW	4	Lat. 8° 37' N, Long. 72° 26' E. Light to moderate monsoon and cloudy weather.
	4 P.M.	29.737	83.0	WSW	4	
	8 P.M.	29.755	84.0	WSW	3	
<i>S. S. Commilla</i>	Midnight	29.807	83.0	WSW	3	Light wind and clear weather. Westerly swell.
	1 A.M.	...	...	SW	...	
	2 A.M.	...	...	SW	...	Heavy squalls of wind and rain.
	3 A.M.	...	...	W	...	
	4 A.M.	29.586	81.5	W	...	Moderate wind and overcast.
	5 A.M.	...	...	WSW	...	*Ditto ditto.
	6 A.M.	...	...	SW	...	Ditto ditto.
	8 A.M.	29.596	82.5	SW	...	Ditto ditto.
	10 A.M.	...	...	SW	...	Heavy SW sea. Ship rolling heavily. Squally, with rain.
	Noon	29.606	83.5	SW	...	Lat. 20° 37' N, Long. 69° 50' E. Course N 56° W. Distance 196 miles. Moderate wind and heavy SW sea. Ship rolling heavily and shipping water fore and aft.
<i>S. S. Darien</i>	4 P.M.	29.586	83.5	SW	...	Moderate wind and squally heavy swell.
	8 P.M.	29.586	82.5	SW	...	Moderate wind and cloudy. Heavy SW sea.
	Midnight	29.576	81.5	SW	...	Strong wind and heavy sea. Squally with heavy rain.
	1 A.M.	...	...	SSW	...	Moderate monsoon and occasional rain showers.
	8 A.M.	29.585	87.0	SSW	...	
<i>S. S. Eden Hall</i>	Noon	...	...	SSW	...	Lat. 18° 40' N, Long. 66° 40' E. Course E by N. Distance 240 miles.
	8 P.M.	29.685	87.0	...	...	
	Midnight	...	...	...	...	Steady monsoon.
	1 A.M.	...	...	SW	...	Fresh breeze and squally with occasional heavy rain and high head sea. Shipping large quantities of water on board filling the decks fore and aft.
	2 A.M.	29.523	81.6	SW	...	
	4 A.M.	29.513	81.6	SW	...	

THE ARABIAN SEA CYCLONE OF

TABLE XXII.—11th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Eden Hall</i> —contd.	6 A.M.	29'533	83'6	SW	...	Strong breeze and squally with occasional heavy rain and high head sea.
	8 A.M.	29'533	85'6	SW	...	
	10 A.M.	29'583	84'6	SW	...	
	Noon	29'573	84'6	SW	...	Lat. 17° 34' N, Long. 66° 31' E. Course S 75° W. Distance 97 miles. Strong wind and squally, with rain at times and partly overcast. Sun occasionally visible.
	1 P.M.	...	...	SW	...	Fresh monsoon with high head sea.
	2 P.M.	29'513	85'6	SW	...	
	4 P.M.	29'493	85'6	SW	...	
	6 P.M.	29'553	84'6	SW	...	Fresh breeze and moderating sea. Ship taking water over bows and gangways only.
	8 P.M.	29'583	84'6	SW	...	
	10 P.M.	29'593	83'6	SW	...	
	Midnight	29'573	83'6	SW	...	Fresh breeze and squally with occasional showers of rain. Head sea.
<i>S. S. Eldia</i>	1 A.M.	...	...	SW	...	Strong breeze. Hard squalls. High confused sea. Ship plunging heavily and taking heavy water over the bows, filling the decks fore and aft.
	5 A.M.	...	...	SW to W	...	
	8 A.M.	...	...	SW to W	...	Strong winds. Hard squalls. Heavy rain and high sea.
	10 A.M.	...	...	WSW	...	Ditto ditto.
	Noon	...	...	WSW	...	Ditto ditto.
	1 P.M.	...	...	SW	...	Lat. 18° 20' N, Long. 66° 19' E. Course S 85° W. Distance 195 miles.
	8 P.M.	...	...	SW	...	At 4 P.M., weather as at 8 A.M.
	9 P.M.	...	...	SSW	...	Moderate wind and clear. High confused sea. Shipping heavy water on deck.
						Ditto ditto, up to midnight.
<i>S. S. Europa</i>	1 A.M.	...	...	S	...	Strong breeze and heavy squalls. High sea. Decks flooded fore and aft. Ship pitching heavily.
	Noon	...	...	S	...	Ditto ditto.
	1 P.M.	...	...	SW	...	Lat. 18° 52' N, Long. 68° 8' E. Course S 86° W. Distance 130 miles.
<i>S. S. Germania</i>	1 A.M.	...	...	WSW	...	Fresh breeze and squalls. Heavy confused sea. Deck flooded fore and aft up to midnight.
	4 A.M.	...	...	WSW	...	Strong wind and high sea.
	8 A.M.	...	...	WSW	...	Strong gale and high cross sea. Shipping heavy quantities of water fore and aft.
	Noon	...	...	...	...	Ditto ditto.
	2 P.M.	...	...	SW	...	Lat. 14° 27' N, Long. 54° 4' E. Course N 70° E. Distance 220 miles. Strong wind and heavy sea. Ship labouring heavily and shipping large quantities of water.
	4 P.M.	...	...	...	...	Wind and weather as at noon.
	8 P.M.	...	...	...	...	Strong winds and heavy sea.
	Midnight	...	...	SW	...	Ditto ditto.
<i>S. S. Henry Bolckow</i>	1 A.M.	...	...	SSW	...	Moderate breeze and fine weather. Very heavy sea. Ship pitching and rolling considerably.
	4 A.M.	29'583	84'5	...	...	At 4 A.M., moderate breeze and cloudy weather. Very heavy sea. Ship pitching and rolling considerably.

TABLE XXII.—11th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	Wind		REMARKS.
				Direction.	Force.	
<i>S. S. Henry Belknap</i> — contd.	3 A.M.	29.583	84.5	...	...	Lat. 22° 47' N. Long. 67° 58' E. Course various. Distance 148 miles. Fresh breeze and heavy swell. Ship rolling heavily at times.
	Noon	29.613	82.5	...	...	
	3 P.M.	...	...	S	...	
	4 P.M.	29.583	84.5	...	...	Light breeze with heavy southerly swell. Ship rolling very much.
	5 P.M.	29.583	84.5	...	...	Cloudy weather. Heavy sea. Ship rolling and pitching very heavily. Squall of rain.
	9 P.M.	...	...	...	...	Moderate breeze and overcast, with rain squalls at intervals. Ship rolling and pitching heavily.
	11 P.M.	...	...	SW	...	
	Midnight	29.585	82.5	...	...	
<i>S. S. Hydaspes</i>	1 A.M.	...	...	SSW	8	
	4 A.M.	29.575	79.9	SSW	8	Strong monsoon gale and ferocious squalls. Ship labouring heavily in a high sea. Shipping quantities of water.
	8 A.M.	29.585	79.9	SSW	8	Ditto ditto.
	Noon	29.615	79.9	SSW	8	Lat. 12° 31' N. Long. 57° 14' E. Course N 62° W. Distance 177 miles. Strong monsoon gale with high beam sea. Ship labouring very heavily and shipping large quantities of water.
	3 P.M.	29.637	78.9	SSW	8	Strong monsoon gale and hard squalls. Ship labouring heavily to a high sea and taking water on board.
	5 P.M.	29.535	79.9	SSW	8	Strong monsoon gale. Hazy, overcast weather. Ship pitching and rolling heavily to high sea and taking much water on board.
	Midnight	29.587	78.9	SSW	7	Strong monsoon and hazy. Ship labouring heavily and shipping much water.
	4 A.M.	29.541	72.0	SSW	7 to 9	Strong gale with high sea, shipping water fore and aft.
<i>S. S. Yumna</i>	8 A.M.	29.550	76.0	SSW	8	Ditto ditto.
	Noon	29.583	74.0	SSW	7	Lat. 15° 29' N. Long. 52° 34' E. Distance 103 miles. Wind and sea slightly decreasing.
	4 P.M.	29.580	75.0	SW	4	Sky becoming overcast and southerly sea getting up.
	8 P.M.	29.625	78.0	SW	3	Weather moderating.
	Midnight	29.480	84.0	Variable	...	Light wind with decreasing sea.
	5 A.M.	...	...	SW	3	
<i>S. S. Nangra</i>	8 A.M.	29.536	84.8	...	...	
	Noon	29.516	84.8	...	...	At Karachi.
	1 P.M.	...	...	SW	...	
	3 P.M.	29.521	86.8	...	...	
	5 P.M.	29.539	83.8	...	...	
<i>S. S. Kerbela</i>	2 P.M.	...	...	SW	3	At Karachi. Moderate breeze and fine weather. Heavy SW swell. Ship pitching heavily at times.
	4 P.M.	29.531	86.9	SW	3	
	6 P.M.	...	...	SW	...	Light breeze and fine weather. Heavy SW swell. Ship pitching and labouring heavily.
	8 P.M.	29.541	86.9	SSW	...	
	Midnight	29.552	85.9	SSW	...	Fresh breeze. High swell from south with passing clouds.
<i>S. Lorna Doone</i>	Noon	29.560	...	S	...	Lat. 19° 50' N. Long. 64° 2' E. Moderate gale. A very heavy sea running.
	6 P.M.	...	...	...	...	Wind and sea moderating.

THE ARABIAN SEA CYCLONE OF

TABLE XXII.—11th June 1887.—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Malwa</i>	4 A.M.	29.688	86.1	...	...	At Bombay. Moderate wind and overcast.
	8 A.M.	29.675	87.1	...	...	Moderate wind, overcast with passing heavy rain squalls.
	Noon	29.693	88.1	...	...	At Bombay moderate wind and overcast with incessant rain.
	8 P.M.	29.707	86.1	SW	...	Fresh wind and overcast. Ship rolling to high SW swell. Passing rain squalls.
	9 P.M.	...	...	...	...	Heavy rain and thick weather.
	Midnight	29.747	86.1	SW	...	Light wind with heavy squalls. Ship rolling to high sea.
<i>S. S. Merton Hall</i>	2 A.M.	...	...	SW	...	Moderate breeze overcast. Moderate SW swell.
	Noon	29.611	87.0	SW	...	Lat. 13° 12' N, Long. 48° 36' E. Course N 80° E. Distance 27.5 miles. Fresh breeze.
	1 P.M.	...	...	WSW	...	Fresh increasing breeze, overcast. Heavy SW sea. Ship rolling heavily and shipping heavy water fore and aft.
	10 P.M.	...	...	Variable	...	
<i>S. S. Morrow</i>	Midnight	...	...	Variable	...	Wind light and variable.* Heavy sea. Vessel rolling very heavily.
	1 A.M.	...	...	SSW	...	
<i>S. S. Navarino</i>	Noon	...	...	SSW	...	Lat. 16° 45' N, Long. 72° 0' E. Course SE by E. Distance 95 miles.
	1 P.M.	...	...	WSW	...	
	8 P.M.	...	...	WSW	...	Hard squalls with rain.
	Midnight	...	...	WSW	...	Moderate gale with tremendously high sea.
	2 A.M.	...	...	...	...	Squally appearance with lightning to SW and NW.
<i>S. S. Nizam</i>	4 A.M.	29.798	88.0	Variable	1	Light breeze with heavy rain.
	8 A.M.	29.818	88.0	Variable	2	Light breeze with dark cloudy weather.
	Noon	29.818	87.0	W	2	Lat. 9° 35' N, Long. 77° 49' E. Distance 23.1 miles. Light breeze and fine weather.
	4 P.M.	29.758	88.0	...	2	Light breeze and cloudy.
	8 P.M.	29.828	88.0	...	2	Ditto ditto.
	Midnight	29.798	88.0	...	2	Light breeze and overcast.
	1 A.M.	...	...	SW	9	Heavy monsoon gale with frequent furious squalls and very high sea. Ship labouring and rolling heavily.
<i>S. S. Nizam</i>	4 A.M.	...	74.3	SW	9	Wind slightly moderated since 3 A.M. Ship labouring to very heavy sea and shipping water at times.
	6 A.M.	...	79.3	SW	9	Wind and sea increasing. Ship labouring heavily.
	7 A.M.	...	...	SW	10	
	8 A.M.	...	79.3	SW	10	Whole gale with terrific sea. Ship labouring and pitching heavily and taking heavy seas overall.
	Noon	...	80.3	SW	10	Lat. 15° 38' N, Long. 58° 57' E. Hard gales with furious squalls. Ship pitching and labouring heavily to very high sea and shipping much water.
	2 P.M.	...	...	SW	10	Ditto ditto.
	4 P.M.	...	77.3	SW	10	Ditto ditto.
	6 P.M.	...	...	SW	10	Ditto ditto.
	8 P.M.	...	...	SW	10	Hard gale with very heavy sea. Ship labouring heavily and shipping seas fore and aft.
	10 P.M.	...	...	SW	10	

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TABLE XXII.—11th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Nizam</i> —contd.	Midnight	...	...	SW	10	Strong gale with hard squalls. Ship pitching and labouring heavily to heavy sea, shipping large quantities of water.
<i>S. S. Nurjahan</i>	1 A.M.	...	...	NW	3	Heavy westerly swell.
	2 A.M.	...	...	NW	6	
	3 A.M.	...	...	NW	4	
	4 A.M.	29'817	77'5	NNW	4	Moderate breeze and showery.
	Noon	...	...	...	...	At Narakal.
	7 P.M.	...	...	N by W	4	Heavy westerly swell.
	8 P.M.	29'837	79'5	N by W	4	Moderate breeze and overcast.
	Midnight	29'837	79'5	N by W	4	Ditto ditto.
<i>S. S. Oriental</i>	Noon	...	...	S	...	Lat. 1° 48' N, Long. 46° 19' E. Moderate breeze and fine clear weather.
<i>S. S. Oswald</i>	1 A.M.	...	...	WSW	...	Fresh breeze and cloudy with heavy swell.
	4 A.M.	29'746	82'1	...	...	Moderate breeze.
	8 A.M.	29'793	83'1	...	...	Moderate breeze and clear.
	Noon	29'773	83'1	...	...	Lat. 17° 53' N, Long. 70° 46' E. Course N 68° E. Distance 213 miles.
	1 P.M.	...	...	WSW	...	Moderate breeze and cloudy.
	4 P.M.	29'743	83'1	...	...	
	8 P.M.	29'766	82'1	...	...	Fresh breeze and squally.
	9 P.M.	...	...	WNW	...	
	10 P.M.	...	...	...	...	Moderate breeze and cloudy.
	11 P.M.	...	...	...	...	Fresh breeze and clear.
	Midnight	29'781	80'4	WNW	...	Moderate breeze and rain.
<i>S. S. Pashumba</i>	1 A.M.	...	...	SW	...	
	4 A.M.	29'630	81'5	...	...	Moderate breeze and cloudy with drizzling rain and heavy confused sea. Ship rolling heavily.
	8 A.M.	29'640	81'5	...	...	Fresh breeze and gloomy overcast weather with confused sea.
	Noon	29'650	81'5	...	...	Lat. 20° 21' N, Long. 70° 30' E. Course S 43° E. Distance 208 miles.
	1 P.M.	...	...	SW	...	Same wind and sea.
	4 P.M.	29'660	84'5	...	...	Moderate breeze and cloudy. Sea going down.
	6 P.M.	...	...	SW	...	
	8 P.M.	29'660	84'5	...	...	Moderate breeze and cloudy, with moderate swell.
	Midnight	29'670	83'5	...	...	Moderate breeze.
<i>S. S. Persia</i>	1 A.M.	29'572	83'1	SW by W	7	Moderate gale with tremendous sea running. Ship rolling and straining heavily and shipping large quantities of water fore and aft.
	3 A.M.	29'552	83'1	SW by W	7	
	5 A.M.	29'552	84'1	SW by W	7	
	7 A.M.	29'532	85'1	SW by W	7	
	8 A.M.	...	...	SW by W	7 to 6	Strong breeze and tremendous sea.

THE ARABIAN SEA CYCLONE OF

TABLE XXII.—11th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Persia</i> —contd.	9 A.M.	29.502	85.1	SW by W	7 to 6	Strong breeze and tremendous sea.
	11 A.M.	29.452	86.1	SW by W	7 to 6	Ditto ditto.
	Noon	...	...	SW by W	7 to 6	Lat. 15° 10' N, Long. 36° 0' E. Course N 67° E. Distance 256 miles.
	1 P.M.	29.452	89.1	SW by W	7 to 6	
	3 P.M.	29.452	87.1	W by W	6	
	4 P.M.	...	...	SW by W	6	Fresh breeze with heavy rain and tremendous sea.
	5 P.M.	29.432	85.1	SW by W	6	Ditto ditto.
	6 P.M.	...	...	SW by W	4 to 5	Ditto ditto.
	7 P.M.	29.432	85.1	SW by W	4 to 5	Ditto ditto.
	9 P.M.	29.402	84.1	SW by W	4 to 5	Ditto ditto.
	11 P.M.	29.402	83.1	SW by W	4 to 5	Ditto ditto.
	Midnight	...	...	SW by W	5 to 6	Wind and sea still the same.
<i>S. S. Purulia</i>	3 A.M.	29.509	93.0	Variable	...	Light variable airs and fine weather.
	6 A.M.	...	...	W to NW	...	Ditto ditto.
	8 A.M.	29.509	91.0	Variable	...	Ditto ditto.
	Noon	29.549	...	S	...	Lat. 27° 18' N, Long. 52° 2' E. Course various. Distance 131 miles. Light breeze, light haze, and smooth water.
	4 P.M.	29.509	93.0	SE	...	Light airs and fine clear weather.
	8 P.M.	29.529	99.0	Calm	...	Calm with hazy horizon.
	Midnight	29.509	97.0	Calm	...	Clear and fine. Hazy with calm weather during first part of watch.
<i>S. S. Rockliff</i>	1 A.M.	...	...	S	...	Moderate wind with rain occasionally. Sea still continues heavy. Vessel labouring heavily.
	8 A.M.	...	...	S	...	Ship not taking much water on board.
	Noon	...	...	S	...	Lat. 18° 16' N, Long. 69° 46' E. Course N. E. Distance 106 miles.
<i>S. S. Rothsay</i>	1 P.M.	...	...	S	...	Weather moderate and showery.
	4 A.M.	...	...	SSW	...	
	4.30 A.M.	...	...	SSW	...	Terrific rain squalls with lightning. Sea very high, making clean breaks over waist and foredeck.
	Noon	29.573	...	SSW	...	Tremendous sea running, completely engulfing the ship fore and aft.
	4 P.M.	...	...	SSW	...	Lat. 16° 6' N, Long. 61° 52' E. Course N 77° E. Distance 225 miles. Wind and sea moderating slightly.
<i>S. S. Salara</i>	Midnight	...	...	SSW	...	Wind moderating. Sea continues very high and confused. Shipping heavy seas at times.
	1 A.M.	...	...	S	...	Wind continues moderate with passing squalls. Sea high and rolling heavily. Atmosphere clear.
	4 A.M.	...	87.3	N	...	Light breeze and fine weather, with southerly swell.
	8 A.M.	...	87.3	N	...	Ditto ditto.
	9 A.M.	...	...	W	...	Ditto ditto.
	Noon	...	88.3	W	...	Ditto ditto.
	1 P.M.	...	...	SW	...	Lat. 24° 32' N, Long. 59° 49' E. Course N 89° W. Distance 224 miles.
	4 P.M.	29.507	89.3	SW	...	Light breeze and fine clear weather. South-easterly swell.

TABLE XXII.—11th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Satara</i> —contd.	8 P.M.	29.497	89.3	SW	...	Light breeze and fine clear weather.
	10 P.M.	...	...	Calm	...	
	Midnight	29.502	91.3	E	...	Light following wind and fine weather.
<i>S. S. Scindia</i>	8 P.M.	29.724	80.0	SW	...	At Bombay. Moderate wind and light thick rain.
	Midnight	29.714	80.0	SW	...	Fresh breeze and rain. Sea heavy. Ship rolling very heavily.
<i>S. S. Sumatra</i>	1 A.M.	...	...	SSW	...	
	2 A.M.	...	...	SSW	...	
	4 A.M.	...	...	SSW	...	Strong wind and fine. High confused sea. Ship labouring and pitching heavily and shipping water fore and aft.
	6 A.M.	...	...	SSW	...	Same weather.
	8 A.M.	...	...	SSW	...	Same weather. Ship labouring very heavily to an immense sea and shipping much water.
	10 A.M.	...	...	SSW	...	Same weather.
	Noon	...	...	SSW	...	Lat. 17° 57' N. Long. 63° 22' E. Course S 79° W. Distance 128 miles. Same weather. High confused sea. Ship labouring heavily.
	2 P.M.	...	...	SSW	...	Same weather.
	4 P.M.	...	...	SSW	...	Ship labouring to high cross sea and shipping water. Same weather.
	6 P.M.	...	...	SSW	...	Same weather.
	8 P.M.	...	...	SSW	...	Ditto.
<i>S. S. Swordsman</i>	10 P.M.	...	...	SSW	...	
	Midnight	...	...	SSW	...	Strong breeze and fine with passing squalls. Ship labouring and rolling heavily.
	1 A.M.	...	...	SSW	5	
<i>S. S. Tarpeia</i>	Noon	29.973	80.3	SSW	5	Lat. 3° 54' S. Long. 41° 27' E. Course NE. Distance 195 miles.
	8 P.M.	29.963	...	SSW	5	
	1 A.M.	...	...	...	...	Moderate gale with hazy weather.
<i>S. S. Victoria</i>	2 A.M.	...	...	SW	...	
	6 A.M.	...	...	SW	...	Fresh gale with high sea.
	Noon	...	...	...	...	Ditto ditto.
	2 P.M.	...	...	SW	...	Lat. 13° 34' N. Long. 53° 5' E. Course N 77° E. Distance 166 miles.
	7 P.M.	...	...	SW	...	Fresh gale with hazy weather and high sea.
	8 P.M.	...	...	...	...	Less wind.
	10 P.M.	...	...	...	...	Fresh gale with hazy weather. Very high sea.
	Midnight	...	...	SW	...	
<i>S. S. Victoria</i>	4-30 A.M.	...	...	...	...	Fresh gale and very heavy westerly sea. Ship labouring very heavily and shipping large quantities of water over all.
	Noon	...	...	...	...	Ditto ditto.
	5-45 P.M.	...	...	...	...	Lat. 15° 50' N. Long. 56° 18' E. Course S 78° W. Distance 70 miles.
	10 P.M.	...	...	W	...	Wind and sea going down.
<i>S. S. Wiscoh</i>	1 A.M.	...	...	SW	...	Light westerly wind with a lumpy sea and light rain. Overcast sky. Ship rolling at times heavily, and taking seas on board.

THE ARABIAN SEA CYCLONE OF

TABLE XXII.—11th June 1887—concluded.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
S. S. <i>Wivcher</i> —contd.	Noon	...	...	WSW	...	Lat. 13° 18' N. Long. 53° 15' E. Course E by N. Distance 237 miles. Strong wind and heavy sea. Ship rolling very much.
	4 P.M.	...	...	...	...	Heavy sea from southward. Ship rolling and labouring very heavily. Wind and weather as at noon.
	Midnight	...	...	...	...	Same wind and weather.

TABLE XXIII.—10 A.M., 12th June 1887.

STATION.	Barometer.	Change in 24 hours.	Abnormal.	WIND.		Thermometer.	Relative humidity.	Cloud.	Rain-fall.	Remarks on the weather at 10 A.M.	
				Direction.	VELOCITY.						
					At 10 A.M.	Mean of day.					
	"	"	"		Miles per hour.	Miles per hour.	°	Per cent.	0 to 10.	"	
Aden . . .	29°650	—'012	...	S	...	10	89°0	64	0	Nil.	
Bushire . . .	'500	—'002	...	WNW	...	...	89°3	61	?	Nil.	
Kurrachee . . .	'551	—'032	—'077	SW	20	15	92°0	62	2	Nil.	Fine weather with passing clouds.
Bhuj . . .	'625	0	—'013	WSW	15	13	77°7	88	10	1°64	Overcast with rain.
Rajkot . . .	'643	0	—'025	SSW	9	6	85°7	70	8	0°14	Cloudy.
Surat . . .	'710	—'009	—'07	SW	L*	...	76°5	95	10	1°37	Overcast with rain.
Bombay . . .	'749	—'048	—'025	W	16	11	82°3	87	10	2°19	Overcast.
Ratnagiri . . .	'791	—'006	—'005	SW	...	10	77°3	95	8	6°99	Heavy rain.
Karwar . . .	'844	—'003	—'014	SW	F*	...	74°1	93	10	3°19	Ditto.
Mangalore . . .	'842	—'042	—'012	Calm	0	3	79°5	85	9	2°33	Threatening weather.
Calicut . . .	'843	—'046	—'043	Calm	...	5	77°1	83	6	0°31	
Cochin . . .	'869	—'042	—'029	NW	L*	...	76°9	84	10	0°43	Dark gloomy weather.
Colombo . . .	'858	+°001	...	WSW	...	10	83°0	71	7	0°06	Fine.
Galle . . .	'850	—'004	...	NW	8	12	81°0	93	3	0°14	
Jacobabad . . .	'497	+°009	—'032	SE	7	9	99°0	39	0	Nil.	Blue sky.
Hyderabad (Sind)	'546	—'023	—'014	SSW	14	...	93°8	40	4	Nil.	Cloudy.
Neemuch . . .	'634	+°009	+°007	WSW	...	...	84°6	59	0	Nil.	Blue sky.
Deesa . . .	'635	—'041	—'021	S	19	19	86°9	57	10	Nil.	Overcast.
Indore . . .	'616	—'020	—'046	W	12	10	83°8	58	10	Nil.	Ditto.
Akola . . .	'661	—'053	—'011	NNW	22	15	83°5	61	10	Nil.	Ditto.
Malegaon . . .	'672	—'038	—'021	W	22	13	85°1	52	5	Nil.	Cloudy.
Poona . . .	'743	—'052	—'022	W	28	20	78°4	69	10	Nil.	Overcast.
Sholapur . . .	'724	+°015	—'034	WNW	17	15	83°6	52	10	Nil.	Ditto.
Belgaum . . .	'786	+°005	—'038	WSW	33	25	72°8	86	10	0°70	Strong wind.
Bellary . . .	'755	—'006	—'031	W	...	16	82°9	53	8	Nil.	Ditto.
Bangalore . . .	'827	—'060	—'004	W	...	11	73°7	77	8	0°03	Fine.
Salem . . .	'839	—'027	—'010	W	...	4	77°5	82	9	0°16	Gloomy.

* For abbreviations see foot-note in page 419.

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TABLE XXIV.—12th June 1887.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Albany</i>	6 A.M.	29.440	82.5	...	...	Very heavy swell from south.
	Noon	29.467	83.3	...	...	Lat. 19° 55' N, Long. 62° 06' E. Course N 62° E.
	4 P.M.	29.448	83.0	...	...	Distance 108 miles.
	8 P.M.	29.497	83.5	...	...	Very heavy swell from south.
<i>S. S. Assam</i>	2 A.M.	...	...	SW	7	
	4 A.M.	29.436	83.7	SW	7	Fresh monsoon gale with hard squalls of wind and rain. Ship labouring heavily and shipping water.
	8 A.M.	29.516	85.7	SW	8	Shipped heavy sea forward at 6.15 A.M.
	9 A.M.	...	...	SW	8	High cross sea. Ship labouring heavily and shipping water.
	10 A.M.	...	...	SW	9 to 8	
	Noon	29.486	84.7	SW	9 to 8	Lat. 16° 27' N, Long. 59° 50' E. Course S 75° W.
						Distance 160 miles. Strong monsoon gale.
	4 P.M.	29.466	84.7	SW	7	High confused sea. Occasionally shipping heavy water and rolling dangerously at times.
	8 P.M.	29.576	85.7	SW	7	No alteration in the weather.
	Midnight	29.616	88.7	SW	7	Strong monsoon gale and overcast. Ship pitching heavily and shipping water.
<i>S. S. Athabasca</i>	1 A.M.	...	...	Variable	...	Strong monsoon gale and overcast. Squally with drizzling rain. Ship rolling heavily at times.
	4 A.M.	...	...	Variable	...	Moderate wind and cloudy.
	Noon	...	...	W by S	...	Hazy light winds.
	1 P.M.	...	...	W by S	...	Lat. 12° 38' N, Long. 45° 27' E. Course various.
	8 P.M.	...	...	W by S	...	Distance 217 miles. Light wind, hot and sultry.
<i>S. S. Bedouin</i>	Midnight	...	...	Variable	...	Light wind and overcast.
	1 A.M.	...	...	Variable	...	Ditto ditto. Slight haze.
	4 A.M.	29.693	86.4	S	4	Light variable winds.
	6 A.M.	...	...	S	5	Light wind and clear weather with light swell from SE.
	8 A.M.	29.763	93.4	S	5	Fresh breeze and following sea.
	9 A.M.	...	...	SW	5	Ditto ditto.
	Noon	29.743	97.4	SW	5	Ditto ditto. Sea increasing.
	1 P.M.	...	...	WSW	5	Lat. 13° 12' N, Long. 48° 40' E. Course N 79° E.
	4 P.M.	29.713	90.4	WSW	5	Distance 238 miles.
	5 P.M.	...	...	SW	5	Fresh breeze and cloudy weather, with heavy following sea. Vessel rolling heavily.
<i>S. S. Britannia</i>	8 P.M.	29.693	88.4	SW	5	Moderate breeze with heavy squalls at intervals.
	9 P.M.	...	...	Variable	2	Dark cloudy weather.
	Midnight	29.703	86.4	Variable	2	Light unsteady wind. Sky overcast and slight sea.
	1 A.M.	...	...	WSW	7	Fresh gale with heavy squalls.
	4 A.M.	29.548	72.4	WSW	9	Blowing a terrific gale with moderate sea.
	5 A.M.	...	...	SW and W	9-	
	6 A.M.	...	...	SW and W	8	

THE ARABIAN SEA CYCLONE OF

TABLE XXIV.—12th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Britannia</i> —contd.	8 A.M.	29.668	72.4	SW and W	8	Heavy gale with squalls of hurricane force. Overcast sky.
	9 A.M.	...	...	SW	7	
	Noon	29.668	70.4	SW	7	Lat. 12° 55' N, Long. 53° 20' E. Continued heavy gale with increasing sea. Ship plunging and rolling heavily, shipping much water fore and aft.
	1 P.M.	...	...	SW and S	7	
	2 P.M.	...	...	SW and S	5	
	3 P.M.	...	...	SW and S	5	Wind and sea moderating.
	4 P.M.	...	74.4	SW and S	5	Strong wind. Hazy weather. Overcast.
	6 P.M.	...	...	SW and S	4	
	8 P.M.	29.548	75.4	SW and S	4	Fresh breeze and squally at times. Dull overcast weather.
	Midnight	29.598	74.4	SW and S	4	Fresh breeze and overcast.
<i>S. S. Canara</i>	4 A.M.	29.767	79.6	Variable	...	Dull cloudy weather and light rain.
	6 A.M.	...	...	...	...	Thick hazy weather. Heavy rain.
	8 A.M.	29.767	78.5	NW	...	Thick rainy weather. Heavy squall. Ship rolling very heavily at times.
	Noon	29.807	79.6	...	...	At Karwar.
	4 P.M.	29.727	72.6	Variable	...	Moderate breeze. Dull wet weather.
	6 P.M.	...	...	...	...	Heavy rain. Moderate breeze.
	8 P.M.	29.787	78.6	...	...	Light breeze. Sky overcast with lightning to SW.
	Midnight	29.777	78.6	...	...	Heavy rain squalls. Moderate SW swell.
	8 A.M.	...	...	Variable	...	Cloudy weather. Passing showers.
<i>S. S. Clan Forbes</i>	4 A.M.	29.602	80.5	Variable	...	Ditto. Ditto.
	8 A.M.	29.652	86.5	Variable	...	
	Noon	29.682	85.5	Variable	...	At Bombay. Light airs and showery.
	6 P.M.	29.702	...	SW	...	
<i>S. S. Clan Graham</i>	2 A.M.	...	...	WSW	...	
	4 A.M.	29.384	85.8	WSW	...	Fierce gale and high dangerous sea. Decks continually flooded with very heavy water.
	6 A.M.	...	...	WSW	...	Ship labouring dangerously and shipping fierce seas fore and aft.
	8 A.M.	29.434	...	WSW	...	
	10 A.M.	29.474	...	WSW	...	
	Noon	29.514	85.8	WSW	...	Lat. 16° 40' N, Long. 58° 21' E. Fierce gale and high dangerous sea running. Ship's decks continually flooded with water fore and aft. Dull gloomy weather with frequent rain squalls.
	2 P.M.	29.544	85.8	WSW	...	
	3 P.M.	...	...	WSW	...	Weather breaking to north-westward.
	4 P.M.	29.564	85.8	WSW	...	Fierce gale and high sea. Shipping very heavy and dangerous water fore and aft.
<i>S. S. Clan Matheson</i>	5 P.M.	...	...	WSW	...	Weather looking more settled.
	8 P.M.	29.614	85.8	WSW	...	Strong hard gale and high sea up to midnight.
	4 A.M.	29.815	84.0	Westerly	3	Light and clear. Westerly swell.
	8 A.M.	29.860	82.0	WSW	3	Ditto. Ditto.

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TABLE XXIV.—12th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Clan Matheson—</i> <i>contd.</i>	Noon	29.852	85.0	WSW	3	Lat. 7° 37' N, Long. 76° 33' E.
	4 P.M.	29.815	84.0	W	3	Light and clear. Westerly swell.
	8 P.M.	29.835	84.0	WSW	3	Ditto ditto.
	Midnight	29.853	81.0	WSW	4	Moderate wind and clear.
<i>S. S. Commilla</i>	2 A.M.	...	...	...	...	Weather squally and looking very dirty.
	3 A.M.	...	...	...	...	Heavy rain, thunder and lightning.
	4 A.M.	29.566	83.5	SW	...	Ditto, ditto, with strong
	8 A.M.	29.566	82.5	SW	...	wind and squalls and heavy SW sea.
	11 A.M.	...	...	...	...	Ditto ditto.
	...	...	...	...	...	Weather clearing. Heavy SW sea.
	Noon	29.576	83.5	SW	...	Lat. 23° 36' N, Long. 67° 19' E. Course N 36° W.
	4 P.M.	29.536	83.5	SW	...	Distance 225 miles. Strong wind and clear.
<i>S. S. Darien</i>	8 P.M.	29.546	83.5	SW	...	Heavy SW sea. Ship rolling heavily.
	Midnight	29.556	82.5	SW	...	Moderate breeze and fine. Heavy SW sea.
	4 A.M.	...	...	SSW	...	Light wind and fine weather.
	Noon	...	...	SSW	...	Ditto ditto.
<i>S. S. Dunbar</i>	Noon	29.644	...	W by S	...	Steady monsoon and heavy rain showers.
<i>S. S. Eddystone</i>	2 A.M.	...	...	Variable	...	Near Bombay.
	6 A.M.	...	...	NW	...	Lat. 18° 12' N, Long. 70° 30' E. Course W by S.
	8 A.M.	...	...	...	...	Distance 130 miles. Strong breeze and cloudy
	Noon	...	...	...	...	with a very high sea. Hard rain and heavy
	2 P.M.	...	...	Variable	...	wind squalls. Sea rough. Weather stormy.
	4 P.M.	...	...	...	...	Variable winds, calm and sultry weather.
	Midnight	...	...	Calm	...	Strong wind and short chopping sea.
<i>S. S. Eden Hall</i>	4 A.M.	...	...	SW	...	Lat. 12° 24' N. Sixty-two miles east of Perim.
	2 A.M.	29.553	82.6	SW	...	Fresh moderate wind and confused sea. Sky
	4 A.M.	29.543	82.6	SW	...	cloudy. Close sultry weather.
	6 A.M.	29.563	82.6	...	...	Calm and hazy.
	7 A.M.	...	...	...	...	Fresh breeze and overcast with high head sea.
	8 A.M.	29.563	83.6	WSW	...	Ditto ditto.
	10 A.M.	29.593	84.6	WSW	...	Ditto ditto.
	Noon	29.603	85.6	WSW	...	Strong breeze and hazy weather with moder-
	1 P.M.	...	...	SW	...	ate head sea. Ship taking sprays over the
	2 P.M.	29.573	84.6	SW	...	bows and through the gangways only.
	4 P.M.	29.543	83.6	SW	...	Lat. 16° 50' N, Long. 65° 6' E. Course S 62° W.
						Distance 92 miles. Fresh breeze and mode-

TABLE XXIV.—12th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Eden Hall</i> —contd.	6 P.M.	29.573	84.6	...	...	Fresh breeze and overcast, rainy weather.
	7 P.M.	...	...	WSW	...	Fresh breeze and overcast, rainy weather.
	8 P.M.	29.603	83.6	WSW	...	Ditto ditto.
	10 P.M.	29.593	82.6	WSW	...	
	Midnight	29.583	82.6	WSW	...	Fresh breeze and squally with rain at times. High head sea. Shipping water over all.
<i>S. S. Etelia</i>	1 A.M.	...	...	SW by S	...	Moderate breeze and clear. High confused sea. Shipping seas over forecastle.
	4 A.M.	...	...	SW by S	...	Moderate breeze and overcast. Sea unchanged.
	6 A.M.	...	...	SW to W	...	
	8 A.M.	...	...	SW to W	...	Strong breeze. Heavy rain squalls. High confused sea. Shipping water fore and aft.
	Noon	29.658	...	SW to W	...	Lat. 17° 47' N, Long. 64° 16' E. Course S 74° W. Distance 122 miles. Moderate to fresh wind. Very high confused sea. Vessel labouring heavily and shipping much water fore and aft.
	1 P.M.	...	...	S to SW and WSW	...	
	4 P.M.	...	...	S to SW and WSW	...	Strong breeze. Heavy squalls. Very heavy confused sea. Ship rolling very heavily and taking heavy water on deck, filling the decks fore and aft.
	Midnight	...	...	S to SW and WSW	...	Moderate to strong winds and squally with rain and very high sea. Ship labouring heavily and taking heavy water on decks, filling them fore and aft.
<i>S. S. Europa</i>	1 A.M.	...	...	SW	...	Fresh breeze and squally. High sea. Decks flooded fore and aft.
	Noon	...	...	SW	...	Ditto ditto. Lat. 28° 45' N, Long. 65° 40' E. Course S, 87° W. Distance 140 miles.
	1 P.M.	...	...	SW	...	Fresh breeze and squally. High confused sea. Ship pitching and rolling heavily. Decks flooded up to midnight.
						Strong gale and high sea.
<i>S. S. Germania</i>	1 A.M.	...	...	...	...	
	2 A.M.	...	...	SW	...	
	4 A.M.	...	...	...	...	Strong gale and high cross sea. Shipping large quantities of water. Ship straining and labouring heavily.
	Noon	...	...	...	...	Lat. 15° 20' N, Long. 57° 59' E. Course N 76° E. Distance 222 miles. Strong wind and very high sea.
	2 P.M.	...	...	SW	...	
	4 P.M.	...	...	...	...	Weather and wind as at noon.
	8 P.M.	...	...	...	...	Strong gale and high sea with passing showers of rain.
	Midnight	...	...	SW	...	Ditto ditto.
<i>S. S. Henry Bolckow</i>	1 A.M.	...	...	SW	...	Strong wind with heavy sea. Ship rolling considerably. Occasional squalls and lightning.
	4 A.M.	29.583	84.5	...	...	
	6 A.M.	...	...	...	...	Cloudy weather. Squalls of rain. Heavy sea. Ship rolling and pitching considerably.
	8 A.M.	29.643	...	...	...	
	Noon	29.673	82.5	...	...	Lat. 21° 7' N, Long. 69° 16' E. Course S 53° E. Distance 160 miles. Fresh breeze and fine weather. Ship rolling heavily to SW swell.
	1 P.M.	...	...	SW	...	
	4 P.M.	29.663	84.5	...	...	Fresh breeze and fine with passing clouds. Ship rolling heavily.

TABLE XXIV.—12th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Henry Bolckow</i> — contd.	6 A.M.	...	...	...	...	Cloudy weather. Moderate wind and sea.
	8 P.M.	29.683	84.5	...	...	
	Midnight	29.693	83.5	...	...	Fresh breeze and fine with passing squalls. Ship rolling heavily at times.
<i>S. S. Hydaspes</i>	1 A.M.	...	...	SSW	7	
	4 A.M.	29.607	78.9	SSW	7	Strong monsoon and squally hazy weather. Ship rolling heavily and taking water over.
	8 A.M.	...	79.9	SSW	7	Ditto ditto.
	Noon	29.612	80.9	SSW	7	Ditto ditto. Lat. 12° 56' N, Long. 53° 58' E. Course N 82° W. Distance 180 miles.
	1 P.M.	...	...	SW	...	
	4 P.M.	29.625	79.9	SW	...	Moderate monsoon and sea. Shipping light sprays.
	8 P.M.	29.637	78.9	SW	...	Moderate monsoon and overcast weather.
<i>S. S. Java</i>	Midnight	29.632	80.9	SW	...	Moderate to fresh monsoon and overcast cloudy weather.
	6 A.M.	...	...	...	...	Light winds and fine clear weather.
	1 P.M.	...	...	SW	...	A: Karachi.
	2 P.M.	29.557	86.1	...	...	
	4 P.M.	29.537	86.1	...	...	Fresh breeze and cloudy with a high swell.
	6 P.M.	29.547	83.1	...	...	Ditto ditto.
	8 P.M.	29.557	83.1	SW and S	...	Ditto ditto.
	10 P.M.	29.607	...	...	...	Wind the same.
	Midnight	29.617	85.1	...	...	Ditto. Sea very high. Squally with heavy rain at times. Ship rolling and pitching heavily at times.
						Fresh increasing wind and sea.
<i>S. S. Jumna</i>	4 A.M.	29.393	83.0	SW	3 to 5	
	8 A.M.	29.509	84.0	SW	3 to 5	Strong head wind and sea.
	Noon	29.524	86.0	W	4	Lat. 12° 48' N, Long. 48° 54' E. Distance 221 miles. Fresh wind and fine weather.
	4 P.M.	29.569	84.0	W	4	Moderate wind and fine weather.
	8 P.M.	29.644	82.0	W	3	Light wind and fine weather.
	Midnight	29.639	84.0	Calm	...	Calm and hazy.
<i>S. S. Kerbela</i>	2 A.M.	...	...	SW	2	Light breeze and fine weather. Heavy south-westerly swell. Ship rolling and pitching heavily at times.
	4 A.M.	29.54*	84.9	SW	2	
	5 A.M.	...	...	W	2	
	8 A.M.	29.611	86.9	SW	2	
	Noon	29.471	86.9	SW	2	Lat. 22° 52' N, Long. 64° 16' E. Course S. 52½° W. Distance 187 miles. Moderate wind and fair weather.
	2 P.M.	...	...	SW	2	Light breeze and fine with heavy S W swell.
	4 P.M.	29.531	86.9	SW	2	
	8 P.M.	29.531	85.9	SW	2	
	Midnight	29.532	85.9	SW	2	Increasing breeze with passing clouds.
	1 A.M.	...	...	WSW	...	Strong breeze with hard squalls and heavy rain. High beam sea. Ship rolling heavily at times.

THE ARABIAN SEA CYCLONE OF

TABLE XXIV.—12th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Malwa</i> —contd.	4 A.M.	29.713	84.1	...	...	Fresh breeze and overcast with passing showers.
	8 A.M.	29.745	83.1	...	...	Strong monsoon and cloudy weather. Sun obscured. Frequent passing rain squalls. Ship rolling heavily to high beam sea.
	Noon	29.791	81.1	...	...	Lat. 15° 49' N, Long. 73° 0' E. Moderate wind and rain. Ship rolling heavily to high beam sea.
	1 P.M.	...	SW	...	...	Moderate wind and overcast with rain.
	3 P.M.	...	...	Various	...	Rainy weather.
	4 P.M.	29.763	80.1	ENE	...	Sharp squall from southward with heavy rain. Moderate high swell.
	6 P.M.	...	81.1	Variable	4 to 6	Fresh unsteady wind. Continuous heavy rain. Ship rolling to south-westerly swell.
	Midnight	29.811	81.1	Variable	2 to 3	Moderate unsteady wind with squalls of heavy rain.
<i>S. S. Merton Hall</i>	1 A.M.	...	...	SW and Variable.	...	Moderate unsteady breeze and overcast sky. High confused sea. Ship plunging and rolling very heavily, and shipping large quantities of water over all.
	8 A.M.	...	...	Variable	...	Strong unsteady breeze and overcast. Heavy rolling and shipping of water continued.
	Noon	29.611	85.0	WSW	...	Lat. 13° 57' N, Long. 52° 49' E. Course N 79½° E. Distance 250 miles.
	2 P.M.	...	...	WSW	...	Fresh monsoon with dull gloomy damp weather and high confused sea. Vessel lurching and rolling heavily, and shipping large quantities of water fore and aft.
	Midnight	...	...	WSW	...	Less wind and sea.
<i>S. R. Morrow</i>	1 A.M.	...	...	WSW	...	Moderate gale with tremendously high sea.
	Noon	...	...	...	...	Ditto ditto. Lat. 15° 0' N, Long. 72° 22' E. Course S 11° E. Distance 108 miles.
	1 P.M.	...	...	SW	...	High sea with hard squalls.
	5 P.M.	...	...	W	...	
	8 P.M.	...	...	W	...	Moderate breeze with rain up to midnight.
<i>S. S. Navarino</i>	4 A.M.	29.808	88.0	WSW	2	
	5.30 A.M.	...	...	.....	...	At Colombo.
<i>S. S. Nizam</i>	1 A.M.	...	...	SW	10	
	4 A.M.	29.484	74.3	SW	10	Hard gale with frequent furious squalls. Heavy sea. Ship labouring heavily and shipping seas at times.
	6 A.M.	29.524	...	SW	10	
	8 A.M.	29.554	...	SW	10	Hard monsoon gale. Very high sea running. Ship labouring and shipping heavy seas fore and aft. Weather overcast and squally.
	10 A.M.	29.564	...	SW	10	A heavy sea struck the ship.
	Noon	29.555	81.3	SW	10	Lat. 15° 8' N, Long. 58° 34' E. Course various. Strong gale with hard squalls. Ship lurching and labouring heavily.
	2 P.M.	29.560	79.3	SW	10 to 11	Heavy monsoon gale with tremendous sea running. Ship labouring heavily and shipping very dangerous seas on board at times.
	4 P.M.	29.560	...	SW	10 to 11	
	7 P.M.	...	...	SW	10 to 11	Hard squall from south-west.
	8 P.M.	29.648	76.3	SW	9	Wind somewhat abating. Squalls less frequent.
	10 P.M.	29.638	...	SW	9	High seas running. Ship labouring heavily.
	Midnight	29.625	77.3	SW	10	Fresh gale with hard squalls at times. Ship pitching and labouring heavily to high sea.

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TABLE XXIV.—12th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Nurjahan</i>	6 A.M.	...	...	N by W	4	Heavy westerly swell.
	2 A.M.	...	...	N by W	6	
	6 A.M.	29.787	78.5	N by W	5	Fresh breeze and squally.
	6 A.M.	...	...	NNW	4	Squally with rain.
	7 A.M.	...	...	NNW	6	
	8 A.M.	29.817	78.5	NNW	6	
	10 A.M.	...	...	WNW	6	
	Noon	29.817	79.5	WNW	6	Lat. 12° 6' N, Long. 74° 55' E. Course various.
	1 P.M.	...	...	N to WNW	5	Distance 145 miles.
	4 P.M.	29.787	76.5	N to WNW	5	Heavy westerly swell.
	8 P.M.	29.837	79.5	N to WNW	3 to 5	Unsteady fresh breeze and squally.
	9 P.M.	...	...	N to NE	3 to 5	Gentle unsteady winds and squally with heavy rain.
<i>S. S. Oriental</i>	Midnight	29.827	79.5	N to NE	3 to 5	
	Noon	...	...	Variable	...	Moderate breeze with occasional hard NNE and NE squalls.
<i>S. S. Oswald</i>	3 A.M.	...	...	...	...	Lat. 3° 33' N, Long. 50° 8' E. Moderate breeze and fine clear weather.
	4 A.M.	29.749	79.7	...	...	Moderate breeze and rain.
<i>S. S. Packumbá</i>	1 A.M.	...	...	SW	...	At Bombay.
	4 A.M.	29.660	83.5	...	...	
<i>S. S. Pandora</i>	8 P.M.	29.680	...	WSW	4	At Bombay. Moderate breeze and rainy thick weather.
	Midnight	29.660	...	WSW	4	At Bombay. Strong breeze, cloudy with rain.
<i>S. S. Persia</i>	6 A.M.	29.402	83.1	WSW	4 to 5	Fresh breeze and tremendous sea.
	3 A.M.	29.452	83.7	WSW	4 to 5	" Ditto ditto.
	4 A.M.	29.502	84.1	WSW	4 to 5	Ditto ditto.
	7 A.M.	29.552	85.7	WSW	4 to 5	Ditto ditto.
	9 A.M.	29.602	85.7	WSW	5	Ditto ditto.
	9.5 A.M.	29.602	86.3	WSW	5	Ditto ditto.
	Noon	...	...	WSW	5	Ditto ditto.
	1 P.M.	29.622	85.1	WSW	5	Lat. 15° 43' N, Long. 60° 7' E. Course N 85° E. Distance 240 miles.
	3 P.M.	29.622	85.1	WSW	5	Fresh breeze and tremendous sea.
	5 P.M.	29.622	85.1	WSW	5	Ditto ditto.
	7 P.M.	29.622	83.1	WSW	5	Ditto ditto.
	9 P.M.	29.632	81.1	WSW	5	Ditto ditto.
	11 P.M.	29.632	81.1	WSW	5	Ditto ditto.
<i>S. S. Purulia</i>	4 A.M.	29.469	93.0	Variable	...	Light airs and fine weather.
	7 A.M.	...	...	...	...	Fresh head wind and fine.
	8 A.M.	29.509	95.0	SE	...	
	Noon	29.549	97.0	...	...	At Lingah. Clear and fine weather.

THE ARABIAN SEA CYCLONE OF

TABLE XXIV.—12th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Purulia</i> —contd.	4 P.M.	29'509	96'0	Variable	...	Light airs and fine weather.
	8 P.M.	29'549	101'0	Calm	...	Very hazy.
	Noon	29'509	99'0	E	...	Light breeze and clear weather.
<i>S. S. Rockcliff</i>	1 A.M.	...	...	SSW	...	Moderate breeze. Heavy sea. Cloudy with occasional rain.
	8 A.M.	...	...	SSW	...	Very hazy. Sea heavy.
	Noon	...	...	SSW	...	At Bombay.
<i>S. S. Rothsay</i>	1 A.M.	...	...	SSW	...	
	4 A.M.	...	...	SSW	...	
	Noon	29'673	...	SSW	...	Moderate wind with confused sea.
	1 P.M.	...	...	SW	...	Lat. 17° 7' N, Long. 65° 11' E. Course N. 71° E. Distance 199 miles. Fresh breeze with heavy SW swell. Hozy weather.
	6 P.M.	...	...	SW	...	Steady breeze and heavy swell.
	Midnight	...	...	SW	...	Fresh breeze and heavy swell. Hazy weather.
	1 A.M.	...	...	ESE	...	
<i>S. S. Satara</i>	4 A.M.	...	97'3	ESE	...	Light breeze and fine weather.
	8 A.M.	29'502	95'3	ESE	...	Ditto ditto.
	9 A.M.	...	...	SSE	...	
	Noon	...	97'3	SSE	...	Lat. 26° 25' N, Long. 56° 46' E. Course various. Distance 203 miles. Moderate following breeze and fine weather.
	1 P.M.	...	...	SSW	...	
	4 P.M.	29'525	94'3	SSW	...	Moderate breeze and fine weather.
	8 P.M.	29'547	97'3	SSW	...	Light breeze and sultry weather.
	Midnight	29'532	91'3	...	...	Light breeze and fine weather.
	1 A.M.	...	...	SW	...	
<i>S. S. Scindia</i>	4 A.M.	29'664	78'0	SW	...	Fresh breeze with passing squalls. Ship rolling heavily.
	6 A.M.	...	...	SW	...	Rainy and squally weather.
	8 A.M.	29'714	80'0	WSW	...	Moderate wind with squalls of wind and rain. Ship rolling heavily. Westerly sea.
	Noon	29'714	83'0	WSW	...	Lat. 17° 0' N, Long. 72° 13' E. Course S 13° E. Distance 123 miles. Fresh breeze and light rain. Ship rolling heavily.
	4 P.M.	29'704	79'0	WSW	...	Rainy and squally throughout.
	7 P.M.	...	...	WSW to W	...	Strong squall of wind and rain.
	8 P.M.	29'774	80'0	...	...	Moderate wind and overcast.
	9 P.M.	...	...	SW	...	Wind hauling to the south.
	Midnight	29'764	81'0	SW	...	Moderate breeze and overcast. Ship rolling heavily.
<i>S. S. Sumatra</i>	1 A.M.	...	...	SSW	...	
	2 A.M.	...	...	SSW	...	
	4 A.M.	...	...	SSW	...	Strong wind and fine weather with passing squalls. Ship labouring to high cross sea.
	6 A.M.	...	...	SSW	...	Ditto ditto

TABLE XXIV.—12th June 1887—concluded.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Sumatra</i> —contd.	8 A.M.	...	...	SSW	...	Strong wind and fine weather with passing squalls. Ship labouring to high cross sea. Passing squalls of wind and rain.
	10 A.M.	...	...	SSW	...	Same weather.
	Noon	...	...	SSW	...	Same weather. Lat. 17° 52' N, Long. 60° 30' E. Course S 88° W. Distance 163 miles.
	2 P.M.	...	...	SSW	...	
	4 P.M.	...	...	SSW	...	Strong wind and overcast with passing squalls of wind and rain. High cross sea. Ship labouring heavily.
	6 P.M.	...	...	SSW	...	Light wind. Thick fog.
	7 P.M.	...	...	Variable	...	Ditto ditto.
	8 P.M.	...	...	WNW	...	Ditto ditto, with heavy swell.
	10 P.M.	...	...	WNW	...	
	Midnight	...	...	WNW	...	Fresh breeze with high south-westerly sea. Fine weather.
<i>S. S. Swordsman</i>	1 A.M.	...	...	SSW	5	
	4 A.M.	29.963	79.0	SSW	5	
	9 A.M.	...	...	SSW	4	
	Noon	29.973	82.0	SSW	4	Lat. 0° 4' S, Long. 43° 37' E.
	1 P.M.	...	...	SSW	4	Moderate breeze.
	3 P.M.	29.963	81.0	SSW	4	
	Midnight	...	...	SSW	4	
<i>S. S. Tarpeia</i>	2 A.M.	...	...	...	...	Fresh gale with very high sea.
	3 A.M.	...	...	SW	...	Ditto ditto.
	10 A.M.	...	...	SW	...	Ditto ditto.
	Noon	...	...	...	...	Lat. 14° 50' N, Long. 56° 26' E. Course N 70° E. Distance 200 miles.
	1 P.M.	...	...	SW	...	Fresh gale with very high sea. Hazy weather.
	6 P.M.	...	...	SW	...	Strong gale with hard squalls and mountainous sea up to midnight.
<i>S. S. Victoria</i>	5 A.M.	...	...	SW	...	Fresh to strong breeze unsteady in force with a high sea. Ship occasionally taking water on board forward. Sky overcast. Light rain at times.
	Noon	...	...	...	...	Lat. 15° 9' N, Long. 54° 21' E. Course S 70° W. Distance 120 miles.
	2 P.M.	...	...	...	...	Strong monsoon with a high sea. Ship taking quantities of water on board forward and aft.
<i>S. S. Wierhoe</i>	1 P.M.	...	...	...	...	Strong wind and hazy weather.
	4 A.M.	...	...	E	...	Heavy squall. Ship taken aback. Vessel rolling and labouring much.
	9 A.M.	...	...	SW	...	
	Noon	...	...	...	...	Lat. 14° 30' N, Long. 53° 56' E. Course E by N. Distance 223 miles. Cloudy with small rain. Cloudy weather.
	4 P.M.	...	...	...	...	
	8 P.M.	...	...	...	...	Weather clear. Wind less.
	Midnight	...	...	...	...	Weather clear and squally. Heavy sea. Ship rolling heavily.

THE ARABIAN SEA CYCLONE OF

TABLE XXV.—10 A.M., 13th June 1887.

STATION.	Barometer.	Change in twenty-four hours.	Abnormal.	WIND.		Thermometer.	Relative humidity.	Cloud.	Rain-fall.	Remarks on the weather at 10 A.M.
				Direction.	Velocity.					
					At 10 A.M.	Mean of day.				
"	"	"	"	"	Miles per hour.	Miles per hour.	°	Per cent.	0 to 10.	
Aden . . .	29'776	+ '126	...	S	...	9	89'4	56	0	<i>Nil.</i>
Bushire . . .	'548	+ '048	...	NW	...	...	89'8	58	?	<i>Nil.</i>
Karachi . . .	'565	+ '014	— '059	WSW	22	20	91'0	65	3	<i>Nil.</i> Fine weather with passing clouds.
Bhuj . . .	'630	+ '005	— '005	SSW	17	13	83'9	76	6	0'13 Cloudy.
Rajkot . . .	'649	+ '006	— '015	SSW	5	10	88'3	57	3	<i>Nil.</i> Ditto.
Surat . . .	'688	— '022	— '036	W	F*	...	86'6	65	8	1'29 Dark gloomy weather.
Bombay . . .	'737	— '012	— '034	W	12	13	83'7	79	8	0'12 Fine weather with passing clouds.
Ratnagiri . . .	'804	+ '013	+ '009	WSW	...	...	74'8	90	10	5'41 Very rough sea.
Karwar . . .	'830	— '014	+ '001	SW	F*	...	73'6	92	10	3'23 Drizzling rain.
Mangalore . . .	'872	+ '030	+ '018	WNW	4	2	73'5	90	10	3'10 Raining.
Calicut . . .	'848	+ '005	— '038	NNW	5	7	77'6	86	6	1'13 Fine weather with passing clouds.
Cochin . . .	'865	— '004	— '046	NW	M*	...	80'0	82	10	0'97
Colombo . . .	'894	+ '036	...	SW	...	11	83'0	71	6	0'19 Fine.
Galle . . .	'907	+ '057	...	NW	10	9	77'5	93	10	0'53
Jacobabad (Sind)	'925	+ '028	0	SW	7	6	98'8	44	0	<i>Nil.</i> Blue sky.
Hyderabad . . .	'606	+ '060	+ '050	SW	14	14	94'2	38	4	<i>Nil.</i> Cloudy
Neemuch . . .	'638	+ '004	+ '014	NNW	...	...	86'1	52	8	<i>Nil.</i>
Deesa . . .	'648	+ '013	— '005	WSW	4	14	88'8	57	8	<i>Nil.</i> Ditto.
Indore . . .	'668	— '008	— '051	NNW	16	9	84'2	58	8	0'02 Ditto.
Akola . . .	'654	— '007	— '026	WNW	24	12	77'8	87	10	0'21 Overcast.
Malegaon . . .	'669	— '003	— '022	W	28	4	82'0	63	10	0'05 Ditto.
Poona . . .	'744	+ '001	— '020	WSW	13	20	78'4	69	10	0'08 Ditto.
Sholapur . . .	'716	— '008	— '041	WNW	19	16	79'9	65	10	0'58 Ditto.
Belgaum . . .	'801	+ '015	— '022	WSW	25	28	68'8	92	10	0'15 Raining.
Bellary . . .	'790	+ '035	+ '004	W	...	21	77'9	70	10	<i>Nil.</i> Overcast.
Bangalore . . .	'826	— '001	— '006	W	...	11	72'7	72	8	0'09 Fine.
Salem . . .	'838	— '001	— '011	SW	...	4	80'5	78	5	0'16 Very clear.

* For abbreviations see foot-note in page 419.

TABLE XXVI.—13th June 1887.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Albany</i> . . .	8 A.M.	29'545	84'0	...	...	Lat. 23° 10' N, Long. 65° 13' E. Course N 42° E. Distance 261 miles.
	Noon	...	...	...	...	
	4 P.M.	29'459	90'0	...	...	

TABLE XXVI.—13th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Assam</i>	1 A.M.	...	...	SW	7	
	4 A.M.	29'366	83'7	SW	7	Fresh monsoon gale. Ship rolling heavily and shipping much water.
	8 A.M.	29'6'6	90'7	WSW	7 to 8	Strong monsoon and overcast. Vessel pitching to high head sea and shipping water.
	Noon	29'526	91'7	WSW	8 to 7	Ditto ditto.
						Lat. 15° 39' N, Long. 57° 59' E. Course S 66° W. Distance 117 miles.
	1 P.M.	...	...	SW by W	7	Same weather.
	4 P.M.	29'626	87'7	SW by W	7	Same weather.
	8 P.M.	29'666	87'7	SW by W	7	Increasing wind and sea. Ship taking sprays over fore and aft.
<i>S. S. Athabasca</i>	Midnight	29'696	87'7	SW by W	6	At 11 P.M., strong breeze and fine weather. Occasionally shipping water forward.
	1 A.M.	...	...	Variable	...	Variable winds and cloudy hazy weather.
	Noon	...	...	SW	...	Lat. 13° 7' N, Long. 49° 27' E. Course N 79° E. Distance 236 miles. Strong wind and overcast.
	4 P.M.	...	...	SW	...	Strong gale and overcast.
	8 P.M.	...	...	SW	...	High sea. Cloudy weather.
<i>S. S. Bedouin</i>	Midnight	...	...	SW	...	Gale. Shipping heavy water fore and aft.
	1 A.M.	...	...	Variable	...	Light winds and cloudy weather. Heavy confused sea.
	4 A.M.	29'693	84'4	...	2	
	6 A.M.	...	...	W	4	
	7 A.M.	...	...	SW	4	
	8 A.M.	29'723	86'4	SW	4	Light to moderate winds with heavy cross sea. Vessel rolling heavily and shipping water on deck fore and aft.
						Ditto ditto.
	9 A.M.	...	...	NE	4	
	Noon	29'664	86'4	NE	4	Lat. 14° 50' N, Long. 52° 22' E. Course N 81° E. Distance 221 miles. Light to moderate winds with heavy cross sea. Vessel rolling heavily and shipping water on deck fore and aft.
	1 P.M.	...	...	SSE	4	Moderate breeze and cloudy sky. Heavy confused sea. Vessel rolling heavily and shipping much water on deck.
	4 P.M.	29'614	84'4	SSE	4	
	7 P.M.	...	...	S	4	
<i>S. S. Bisagno</i>	8 P.M.	29'644	86'4	S	6	Strong breeze and very heavy beam sea. Vessel rolling heavily and shipping very heavy sea on deck. Sky clear.
	Midnight	29'664	86'4	S	6	Ditto ditto.
	7 P.M.	...	73'7	SW	3	At Bombay. High sea with strong wind and rain. Ship rolling.
	11 P.M.	...	77'3	SW	4	Ditto ditto.
<i>S. S. Britannia</i>	1 A.M.	...	...	SW	4	
	4 A.M.	...	79'4	SW	4	Smart breeze. Hazy weather. Moderate sea.
	7 A.M.	...	...	WSW	4	
	8 A.M.	29'648	82'4	WSW	4	
	11 A.M.	...	...	W	4	
	Noon	29'668	82'4	W	4	Lat. 12° 42' N, Long. 49° 59' E. Course S 85° W. Distance 187 miles. Fresh breeze and hazy weather. Head sea. Shipping water at times.
	3 P.M.	...	...	W by N	4	

THE ARABIAN SEA CYCLONE OF

TABLE XXVI.—13th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermo- meter.	Wind.		REMARKS.
				Direction.	Force.	
<i>S. S. Britannia</i> —contd.	4 P.M.	29.648	82.4	W by N	4	Fresh breeze and hazy weather. Moderate head sea.
	8 P.M.	29.648	82.4	W by N	4	Ditto ditto.
	9 P.M.	...	...	WSW	3	
	Midnight	...	82.4	WSW	3	Moderate breeze and clear fine weather.
<i>S. S. Calder</i>	10 P.M.	...	...	SW	...	Near Bombay.
	Midnight	...	...	...	...	Overcast and raining. Very heavy SW sea. Vessel rolling and straining heavily and shipping heavy seas over all.
<i>S. S. Canara</i>	4 A.M.	29.747	78.6	Variable	...	Light breeze and cloudy wet weather.
	8 A.M.	29.787	78.6	Variable	...	Light rain throughout.
	Noon	29.787	79.6	Variable	...	Near Mangalore. Dull cloudy weather. Passing showers.
	1 P.M.	...	...	...	...	Moderate breeze and squally weather.
	4 P.M.	29.777	79.6	Variable	...	Moderate breeze and wet weather.
	8 P.M.	29.807	78.6	WNW	...	Strong breeze and dark squally weather. Rain throughout.
	Midnight	29.827	78.6	Variable	...	Rain throughout, wind moderating.
	1 A.M.	...	...	WSW	...	Strong hard gale, with fierce squalls of wind and heavy rain. High sea running. Shipping very heavy water fore and aft. Ship straining very much.
<i>S. S. Clan Graham</i>	2 A.M.	29.664	...	WSW	...	
	4 A.M.	29.664	85.8	...	...	
	6 A.M.	...	...	WSW	...	Hard gale with high sea. Vessel continually under water.
	Noon	...	...	WSW	...	Ditto ditto.
	4 P.M.	29.697	84.8	WSW	...	Lat. 16° 56' N, Long. 58° 21' E.
	5 P.M.	...	...	WSW	...	Strong gale with terrific mountainous sea breaking over the ship fore and aft.
	8 P.M.	...	...	WSW	...	Ditto ditto.
	4 A.M.	29.868	79.0	...	3	Decks continually flooded with heavy water. Light wind and clear weather with passing clouds.
<i>S. S. Clan Matheson</i>	Noon	29.877	83.0	...	...	At Colombo.
	8 P.M.	29.855	84.0	...	...	
	4 A.M.	29.536	82.5	SW	...	
<i>S. S. Commilla</i>	8 A.M.	...	...	...	...	At Bombay. Light wind and fine.
	8 A.M.	29.576	82.5	SW	...	
	Noon	29.594	...	Variable	...	Lat. 17° 50' N, Long. 68° 8' E. Course W by S. Distance 143 miles. Blowing very strong, and at times with hurricane force. Steamer pitching and filling the deck from stem to stern. Furious squalls. Barometer very unsteady. Wind veering between WSW and West by North.
<i>S. S. Eddystone</i>	1 A.M.	...	...	Calm	...	Sky overcast. Weather very close and sultry.
	4 A.M.	...	...	Variable	...	At 6 A.M. Sea confused.
	Noon	...	...	W	...	Lat. 12° 9' N, Long. 48° 12' E. Course S 84° E. Distance 280 miles.
	4 P.M.	...	...	...	...	Light breeze and overcast. Weather very close and warm.
	Midnight	...	...	W	...	Fresh breeze. Strong sea coming astern.

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TABLE XXVI.—13th June 1887—continued.

NAME OF VESSEL.	HOUR.	Barometer.	Thermo- meter.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Eden Hall</i>	1 A.M.	...	...	SW by W	...	Strong winds and squally, with occasional heavy showers of rain. High head sea.
	2 A.M.	29.573	81.6	SW by W	...	
	4 A.M.	29.553	81.6	SW by W	...	
	6 A.M.	29.583	82.6	SW by W	...	At 7 A.M., fresh breeze and high sea with hazy weather. Heavy spray coming over the bows and through the gangways.
	8 A.M.	29.613	83.6	SW by W	...	
	10 A.M.	29.613	83.6	SW by W	...	
	Noon	29.593	83.6	SW by W	...	Lat. 16° 19' N, Long. 63° 50' E. Course S 67° W. Distance 80 miles. Fresh breeze and overcast with high head sea. Ship pitching and straining and taking much water on board.
	2 P.M.	...	...	SW by S	...	Fresh breeze and squally with passing showers of rain and high head sea. Ship taking heavy spray.
	2 P.M.	29.583	81.6	SW by S	...	
	4 P.M.	29.553	81.6	SW by S	...	
	5 P.M.	...	...	SW	...	
	6 P.M.	29.573	81.6	SW	...	Strong breeze and squally.
	7 P.M.	...	...	WSW	...	At 7.30 P.M., flash of lightning seen to the westward.
	10 P.M.	29.613	81.6	WSW	...	
	Midnight	29.593	80.6	WSW	...	Strong winds and heavy squalls with rain and high head sea.
<i>S. S. Etolia</i>	1 A.M.	...	...	WSW	...	Strong breeze and squally. High dangerous sea. Ship filling the decks fore and aft.
	6 A.M.	...	...	WSW	...	Moderate to fresh winds.
	Noon	29.697	...	WSW	...	Strong breeze and squally. High head sea. Shipping heavy water on forward decks. Lat. 17° 29' N, Long. 62° 26' E. Course S 80° W. Distance 106 miles.
	4 P.M.	...	...	WSW	...	Strong breeze. High confused sea. Ship rolling and straining heavily and taking large quantities of water over the bows, filling the decks fore and aft.
	7.30 P.M.	...	...	WSW	...	Shipped two heavy seas in succession, completely filling decks fore and aft.
	10 P.M.	...	...	WSW	...	Weather continuing the same.
<i>S. S. Europa</i>	Midnight	...	...	WSW	...	Dark cloudy night. High confused sea. Ship rolling heavily.
	1 A.M.	...	...	South Westerly	...	Fresh breeze and heavy sea. Decks flooded fore and aft and ship pitching heavily.
	6 A.M.	...	...	South Westerly	...	Same weather, with heavy rain squalls.
	Noon	...	...	South Westerly	...	Lat. 18° 40' N, Long. 63° 23' E. Course S 88° W. Distance 130 miles. Strong wind and high seas. Shipping very heavy water fore and aft.
	4 P.M.	...	...	South Westerly	...	Strong breeze and rain squalls with very heavy confused sea. Decks flooded fore and aft and ship pitching and lurching heavily.
<i>S. S. Germania</i>	1 A.M.	...	...	SW	...	Strong gale and high cross sea. Shipping heavy seas fore and aft.
	4 A.M.	...	...	...	...	Strong winds and heavy sea with heavy showers of rain.
	8 A.M.	...	...	...	...	Wind and sea moderating a little.
	Noon	...	...	...	...	Lat. 16° 14' N, Long. 61° 43' E. Course N 76° E. Distance 222 miles. Strong wind and sea.
	2 P.M.	...	...	SW	...	
	4 P.M.	...	...	...	...	Strong wind and heavy cross sea. Shipping heavy quantities of water.

THE ARABIAN SEA CYCLONE OF

TABLE XXVI—13th June 1887.—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Germania</i> —contd.	8 P.M.	...	...	...	...	Strong wind and high sea, with heavy showers of rain.
	Midnight	...	...	SW	...	Ditto ditto.
<i>S. S. Henry Bolckow</i>	1 A.M.	...	...	SW	...	Moderate breeze and fine weather with passing clouds.
	4 A.M.	29'683	83'5	SW	...	Moderate wind and sea. Weather cloudy.
	8 A.M.	29'703	84'5	...	...	
	Noon	29'723	82'5	...	...	Lat. 18° 43' N, Long. 71° 50' E. Course S 46° E. Distance 206 miles. Moderate wind and fine weather.
	1 P.M.	...	...	WSW	...	
	4 P.M.	29'673	81'5	...	...	Moderate wind and fine weather.
	Midnight	29'683	81'5	...	...	
<i>S. S. Hydaspes</i>	1 A.M.	...	...	SW	4	
	4 A.M.	29'609	81'9	SW	4	Moderate breeze and cloudy SW swell.
	8 A.M.	29'594	83'9	SW	5	Fresh wind and fine. Westerly swell.
	Noon	29'691	84'9	SW	5	Lat. 12° 57' N, Long. 49° 48' E. Course west. Distance 266 miles. Moderate wind and hazy. Westerly swell.
	1 P.M.	...	...	WSW	4	
	4 P.M.	29'644	83'9	WSW	4	Moderate wind and fine. Head sea.
	8 P.M.	29'636	86'9	WSW	4	Ditto ditto.
	Midnight	29'676	82'9	WSW	3	Ship pitching and taking water forward. Light to moderate wind and fine weather. Slightly hazy on the horizon.
<i>S. S. Java</i>	1 A.M.	...	...	SW	...	
	2 A.M.	29'587	84'1	...	...	
	4 A.M.	29'577	84'1	...	...	Fresh breeze with a high sea, and squally with heavy rain. Ship rolling and pitching heavily.
	6 A.M.	29'597	83'1	...	...	
	8 A.M.	29'617	84'1	...	...	Fresh breeze with cloudy weather. Passing squalls at times. High beam sea.
	10 A.M.	29'647	85'1	...	...	Same wind and weather.
	Noon	29'647	84'1	...	...	Lat. 21° 37' N, Long. 69° 33' E. Course various. Distance 250 miles. Same wind and weather. Ship rolling and pitching heavily.
	1 P.M.	...	...	SW	...	
	2 P.M.	29'637	88'1	...	...	
	4 P.M.	29'637	88'1	...	...	Moderate breeze, with a high beam sea.
	6 P.M.	29'627	86'1	...	...	Same wind and weather.
	8 P.M.	29'597	83'1	...	...	Ditto ditto.
	10 P.M.	29'637	84'1	...	...	Ditto ditto.
	Midnight	29'637	84'1	...	...	Ditto ditto, with occasional rain. Ship rolling heavily.
<i>S. S. Jumna</i>	2 A.M.	...	...	S	...	Southerly breeze springing up.
	4 A.M.	29'649	80'0	S	3	
	8 A.M.	29'724	82'0	S	5	Moderate wind, and fine weather.
	Noon	29'773	86'0	S	6	Lat. 12° 46' N, Long. 48° 12' E. Distance 216 miles. Fine, but hazy.
	2-30 P.M.	...	...	SW	4	At Aden.

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TABLE XXVI.—13th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
S. S. <i>Kerbela</i>	2 A.M.	...	...	SW	3	Moderate breeze and fine. Heavy SW swell. Ship taking water over fore-castle head.
	4 A.M.	29'571	83'9	SW	3	At 6 A.M. Dull cloudy weather and passing showers.
	8 A.M.	29'611	85'9	SW	3	
	Noon	29'557	86'9	SW	3	Lat. 20° 58' N, Long. 61° 37' E. Course S 51½° W. Distance 185 miles. Moderate breeze. High sea from S.W. Ship rolling heavily and shipping water over the bow and aft.
	2 P.M.	...	...	SW	2	Light breeze, and fine clear weather with heavy SW swell. Ship labouring heavily at times.
	4 P.M.	29'521	86'9	SW	2	
	6 P.M.	...	...	Variable	1	
	7 P.M.	...	...	NE	3	Light breeze and cloudy.
	8 P.M.	29'541	87'9	Variable	3	
	Midnight	29'571	85'9	Variable	3	Cloudy with a confused swell.
S. S. <i>Malwa</i>	1 A.M.	...	...	E	4	Moderate wind, and overcast sky. Ship rolling to south-westerly swell.
	4 A.M.	29'788	82'1	...	...	Moderate wind and overcast, with passing squalls of rain from westward.
	7 A.M.	...	...	E	...	
	8 A.M.	29'840	81'1	Variable	4 to 5	Moderate wind, and overcast.
	Noon	29'862	82'1	W	3 to 4	Ditto ditto with passing squalls of rain. Lat. 11° 49' N, Long. 74° 50' E. Course S 24° E. Distance 263 miles.
	4 P.M.	29'795	83'1	...	...	Less sea, but same weather.
	8 P.M.	29'815	83'1	WNW	...	Moderate breeze and overcast sky.
	Midnight	29'827	82'1	...	...	Light wind and cloudy. Passing rain showers.
S. S. <i>Merton Hall</i>	1 A.M.	...	...	SW	...	Strong monsoon. Dark gloomy weather and very high increasing sea. Vessel still rolling heavily and shipping heavy seas over all.
	Noon	29'671	82'0	SW	...	Lat. 15° 11' N, Long. 57° 4' E. Same wind and weather.
	1 P.M.	...	...	SW	...	Strong monsoon, overcast, and very high sea. Vessel rolling and shipping large quantities of water fore and aft.
	Midnight	...	...	SW	...	Same weather.
S. R. <i>Morse</i>	1 A.M.	...	...	W	...	
	6 A.M.	...	...	NNW	...	
	Noon	...	...	WNW	...	Lat. 13° 20' N, Long. 74° 5' E. Course S 44° E. Distance 112 miles.
	4 P.M.	...	...	SW	...	Overcast.
	6 P.M.	...	...	Variable	...	Ditto.
	Midnight	...	...	Variable	...	Hard squalls.
	2 A.M.	29'625	...	SW	8	
S. S. <i>Nisam</i>	3 A.M.	...	...	SW	8	Moderate gale with frequent squalls. High sea. Ship labouring heavily.
	4 A.M.	29'628	76'3	SW	7	Wind and sea increasing slightly.
	5:30 A.M.	...	...	SW	7	Wind and sea moderating somewhat.
	8 A.M.	29'712	78'3	SW	7	Moderate monsoon gale. High sea running. Ship rolling and lurching heavily. Weather fine but cloudy; squally at times.
	9 A.M.	29'832	...	SW	7	

THE ARABIAN SEA CYCLONE OF

TABLE XXVI.—13th June 1887—continued.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	Wind.		REMARKS.
				Direction.	Force.	
S. S. Nizam—contd.	10 A.M.	29.762	...	SW	7	Lat. 13° 12' N, Long. 60° 24' E. Course N 75° E. Distance 83 miles. Moderate monsoon gale. Ship lurching heavily. Strong monsoon with high following sea. Ship rolling heavily at times. Same weather.
	11 A.M.	29.762	...	SW	2	
	Noon	29.699	83.3	SW	7	
	1 P.M.	...	...	SW	9	
	4 P.M.	29.699	79.3	SW	9	
	7 P.M.	...	...	SW	7	
	8 P.M.	29.739	79.3	SW	7	
	11 P.M.	...	...	SW	9	
	Midnight	29.739	79.3	SW	9	
S. S. Nurjahan .	1 A.M.	...	...	N to NW	5	Strong monsoon with hard squalls of wind and rain. High sea running. Heavy westerly swell.
	3 A.M.	...	...	W	4	
	4 A.M.	29.807	79.5	...	...	
	6 A.M.	...	...	NW	4	
	11 A.M.	...	...	W	6	
	Noon	29.827	81.5	W	...	
	1 P.M.	...	...	W	5	
	2 P.M.	...	...	...	4	
	3 P.M.	...	...	NNW	3	
	4 P.M.	29.757	79.5	...	3	
	6 P.M.	...	...	...	4	
	8 P.M.	...	...	W	5	
	11 P.M.	...	...	WNW	5	
	Midnight	29.797	78.5	...	5	
	Noon	...	...	...	...	
S. S. Oriental .	8 P.M.	...	...	...	...	
	9-30 P.M.	...	...	...	...	
	...	...	...	...	...	
S. S. Pandora .	5 A.M.	29.660	...	WSW	4	Moderate breeze and fine clear weather. Lat. 6° 58' N, Long. 49° 36' E. Fresh breeze and fine clear weather. Strong breeze and squally.
	6 A.M.	29.863	...	WSW	4	
	8 A.M.	29.863	...	WSW	4	
	10 A.M.	29.660	...	WSW	4	
	Noon	29.660	...	WSW	4	
	1 P.M.	29.640	...	WSW	6	
	5 P.M.	29.640	...	W	7	
	7 P.M.	29.660	...	W	7	
	11 P.M.	29.640	...	W	7	
S. S. Persia .	1 A.M.	29.632	81.1	WSW	4 to 5	Wind and sea moderating
	...	...	...	...	...	

THE 4TH TO 13TH JUNE 1887.

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TABLE XXVI.—13th June 1887—continued.

NAME OF VESSEL.	Hour.	Baromet.	Thermomet.	Wind.		REMARKS.
				Direction.	Force.	
S. S. Persia—contd.	3 A.M.	29.652	81.1	WSW	4 to 5	Wind and sea moderating.
	5 A.M.	29.652	81.1	WSW	4 to 5	Ditto.
	7 A.M.	29.652	83.1	WSW	4 to 5	Ditto.
	8 A.M.	...	...	WSW	4	Wind and sea moderate.
	9 A.M.	29.652	83.2	WSW	4	Ditto.
	11 A.M.	29.652	83.4	WSW	4	Wind and sea moderate.
	Noon	...	...	WSW	3 to 4	Ditto ditto. Lat. 16° 59' N, Long. 64° 10' E. Course N 71° E. Distance 245 miles.
	4 P.M.	29.672	84.1	WSW	3 to 4	
	3 P.M.	29.672	83.5	WSW	3 to 4	
	4 P.M.	...	...	WSW	3 to 4	Strong breeze with heavy rain. Shipping water fore and aft, and straining heavily.
	5 P.M.	29.672	83.1	WSW	4	Ditto ditto.
	7 P.M.	29.672	81.1	WSW	4	At 8 P.M. Ditto ditto.
	9 P.M.	29.672	81.1	WSW	4	
	Midnight	29.672	81.1	WSW	4 to 5	Fresh breeze and sea.
S. S. Purulja	4 A.M.	29.509	93.0	Variable	...	Light variable airs and fine weather.
	8 A.M.	29.529	97.0	...	...	
	Noon	29.529	101.0	...	...	At Bunder Abbas. Clear and fine.
	4 P.M.	29.549	101.0	Calm	...	Ditto.
	8 P.M.	29.549	95.0	Calm	...	Ditto.
S. S. Rothsay	Midnight	29.509	95.0	Calm	...	
	4 A.M.	...	...	SSW	...	
	4 A.M.	...	...	SSW	...	Steady wind with passing rain squalls.
	Noon	29.693	...	SSW	...	Lat. 17° 55' N, Long. 68° 40' E. Course N 76° E. Distance 206 miles. Steady wind and clear. Heavy SW swell.
	1 P.M.	...	...	SW	...	
S. S. Satara	4 P.M.	...	...	SW	...	Gloomy weather with showers and heavy SW swell.
	Midnight	...	...	SW	...	Drizzling rain and hazy weather.
	1 A.M.	...	...	SSW	...	
	4 A.M.	29.532	91.3	...	...	Light breeze and fine weather.
	8 A.M.	29.552	95.3	...	...	At Bunder Abbas.
S. S. Scindia	1 P.M.	...	...	SSW	...	
	4 P.M.	29.520	96.3	SSW	...	Light breeze and fine weather.
	8 P.M.	29.558	95.3	SSW	...	Ditto ditto.
	10 P.M.	...	...	SW	...	
	Midnight	29.547	89.3	SW	...	Light head wind and hazy weather.
	4 A.M.	...	...	WSW	...	Moderate breeze and overcast. Heavy westerly swell. Ship rolling heavily.
S. S. Scindia	4 A.M.	29.724	79.0	WSW	...	

THE ARABIAN SEA CYCLONE OF

TABLE XXVI.—13th June 1887—continued.

NAME OF VESSEL.	HOUR.	Barometer.	Thermo- meter.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Scindia</i> —contd.	8 A.M.	29.794	80.0	WSW	...	Sharp squalls of wind and rain. Ship rolling heavily.
	Noon	29.804	80.0	WSW	...	Lat. 13° 44' N, Long. 73° 27' E. Course S 18° E. Distance 210 miles. Moderate breeze with passing squalls. Sun obscured all day.
	4 P.M.	29.764	77.0	WSW	...	At 3 P.M. moderate wind with passing squalls.
	5 P.M.	...	...	W	...	
	7 P.M.	...	...	W	...	Very heavy squalls of wind and rain.
	8 P.M.	29.834	78.0	W	...	Moderate wind with frequent strong squalls of wind and rain.
	Midnight	29.834	80.0	W	...	Moderate breeze with light drizzling rain throughout. Ship rolling heavily.
<i>S. S. Sumatra</i>	1 A.M.	...	...	W	...	
	2 A.M.	29.605	...	...	...	
	4 A.M.	29.645	...	WSW	...	Strong wind with passing squalls of wind and rain. High confused sea. Ship labouring.
	6 A.M.	29.655	...	WSW	...	Same wind and weather.
	8 A.M.	29.675	...	WSW	...	Ditto ditto.
	10 A.M.	29.705	...	WSW	...	
	Noon	29.665	...	WSW	...	Lat. 16° 59' N, Long. 57° 40' E. Course S 71° W. Distance 162 miles. Fresh breeze and overcast. Hazy horizon. Heavy head sea. Ship rolling heavily at times.
	2 P.M.	29.655	...	WSW	...	Same weather.
	6 P.M.	29.605	...	WSW	...	Ditto.
	8 P.M.	29.605	...	WSW	...	Ditto. Ship rolling to SW swell.
	9 P.M.	...	...	SW	...	
	10 P.M.	29.605	...	SW	...	
<i>S. S. Swordsman</i>	Midnight	29.605	...	SW	...	Fresh breeze and fine clear weather. High sea. Ship rolling heavily at times.
	1 A.M.	...	...	SSW	3	
	4 A.M.	29.963	79.0	SSW	3	
	7 A.M.	...	...	SSW	2	
	Noon	29.973	83.0	SSW	2	Lat. 3° 40' N, Long. 47° 32' E. Course N 47° E. Distance 224 miles.
	1 P.M.	...	...	SW	3	Light breeze and hazy.
	8 P.M.	29.963	82.0	SW	3	
<i>S. S. Taif</i>	Midnight	...	...	SW	3	
	1 A.M.	...	...	SSE	...	Light wind and overcast sky. Sea moderate.
	8 A.M.	29.958	...	SSE	...	Sky overcast. Showery appearance.
	10 A.M.	...	...	SSE	...	Sea moderate.
	11 A.M.	...	...	Variable	...	Light wind.
	Noon	29.948	...	...	...	Lat. 0° 39' S Long. 62° 34' E. Course N 19° E. Distance 186 miles.
	4 P.M.	...	...	Variable	...	Light wind and cloudy. Moderate sea.
	7 P.M.	...	...	SE	...	
	8 P.M.	29.978	...	SE	...	Fresh wind and overcast sky. Clear horizon. Sea moderate.
	Midnight	...	...	SE	...	

TABLE XXVI.—13th June 1887.—concluded.

NAME OF VESSEL.	Hour.	Barometer.	Thermometer.	WIND.		REMARKS.
				Direction.	Force.	
<i>S. S. Tarpeia.</i>	1 A.M.	...	...	SW	...	Wind more moderate. Sea very high. Ship rolling very heavily.
	6 A.M.	...	...	SW	...	Fresh gale with passing showers and high sea.
	Noon.	...	...	SW	...	Ditto ditto.
	1 P.M.	...	...	SW	...	Lat. 15° 52' N, Long. 66° 8' E. Course N 80° E.
	8 P.M.	...	...	SW	...	Fresh gale with squally weather and high sea.
	Midnight	...	...	SW	...	Ditto ditto.
<i>S. S. Victoria</i>	1 A.M.	...	...	...	...	Moderate gale and overcast with a heavy head sea. Ship pitching heavily and shipping much water.
	Noon	...	...	...	...	Lat. 14° 5' N, Long. 53° 7' E. Course S 49° W. Distance 56 miles.
	6 P.M.	...	...	SSW	...	Fresh breeze. Sea going down to a long low swell from SSW. Hazy atmosphere with a clear sky.
<i>S. S. Wicenhoe</i>	1 A.M.	...	...	SW	...	Strong wind and heavy SW sea. Vessel rolling and labouring.
	8 A.M.	...	...	SW	...	Cloudy with glimpses of sun. Same weather.
	Noon	...	...	N	...	Weather same.
	1 P.M.	...	...	N	...	Lat. 14° 46' N, Long. 57° 45' E. Course E by N ½ N. Distance 227 miles.
	Midnight	...	...	...	...	Strong wind and squally with rain up to evening.

TABLE XXVII.—Abnormal wind components in miles per hour.

1887. June.	Wind component direction.	Jacobabad.	Hyderabad.	Kurrachee.	Deesa.	Bhuj.	Indore.	Akota.	Malagan.	Bombay.	Poon.	Shahpur.	Ranagiri.	Belgaum.
Date.														
1	N .	+ 0.3	- 7.1	+ 0.6	- 14.4	- 8.6	- 8.4	+ 13.3	+ 8.3	+ 5.4	+ 6.2	- 2.0	+ 5.9	+ 8.1
	E .	+ 4.8	+ 0.6	- 5.8	- 1.3	- 17.3	+ 0.2	- 5.6	+ 4.3	+ 4.0	- 1.6	- 1.4	- 2.6	- 4.1
2	N .	+ 2.4	+ 4.9	+ 0.6	- 18.1	- 9.0	- 10.3	+ 13.3	+ 11.5	+ 8.8	+ 6.2	+ 2.2	+ 8.2	- 2.6
	E .	- 1.7	- 12.8	- 5.8	- 2.9	- 18.7	+ 4.8	- 5.6	+ 0.8	+ 0.7	- 7.6	+ 3.4	+ 1.9	- 4.0
3	N .	+ 2.4	+ 4.6	+ 13.2	- 11.6	+ 6.3	- 7.7	+ 10.6	+ 1.2	+ 2.3	+ 1.6	+ 3.4	+ 2.1	+ 15.8
	E .	+ 7.3	+ 2.9	- 0.3	- 0.2	- 15.7	+ 0.9	+ 6.3	+ 2.5	+ 1.6	+ 4.3	+ 0.7	- 1.8	+ 14.4
4	N .	+ 2.5	- 2.9	+ 4.4	- 8.0	+ 6.3	+ 0.8	- 0.1	- 5.4	+ 8.5	+ 2.7	- 3.9	- 2.6	+ 7.5
	E .	+ 3.2	- 7.6	+ 3.5	+ 1.3	- 3.7	- 0.6	+ 0.8	+ 9.3	+ 1.6	+ 11.9	+ 9.0	- 1.1	+ 21.0
5	N .	+ 3.9	- 1.5	- 3.1	+ 2.5	+ 5.7	+ 6.5	- 0.2	- 3.3	- 2.0	+ 6.2	- 10.0	- 8.1	- 22.2
	E .	+ 2.0	- 6.2	+ 8.4	+ 1.5	+ 6.3	+ 3.7	+ 7.9	+ 15.6	+ 5.9	+ 26.4	+ 13.6	+ 7.4	+ 14.4
6	N .	+ 5.2	- 3.6	- 8.0	+ 9.6	- 5.0	+ 0.8	- 5.1	- 1.2	+ 5.4	+ 6.2	- 12.2	+ 2.1	- 13.8
	E .	- 2.8	- 8.3	+ 15.9	+ 2.4	+ 7.0	+ 7.4	+ 5.8	+ 17.5	+ 13.0	+ 5.4	+ 17.8	- 1.8	+ 2.2
7	N .	- 4.0	+ 0.2	+ 4.4	+ 8.1	- 0.8	- 6.6	- 15.3	- 7.6	+ 0.8	+ 3.5	- 14.0	- 14.1	- 10.1
	E .	+ 4.7	+ 3.7	+ 3.5	+ 4.9	+ 11.2	+ 6.3	+ 17.0	+ 19.9	+ 20.1	+ 21.9	+ 8.6	+ 5.4	+ 3.7

TABLE XXVII.—*Abnormal wind components in miles per hour—concluded.*

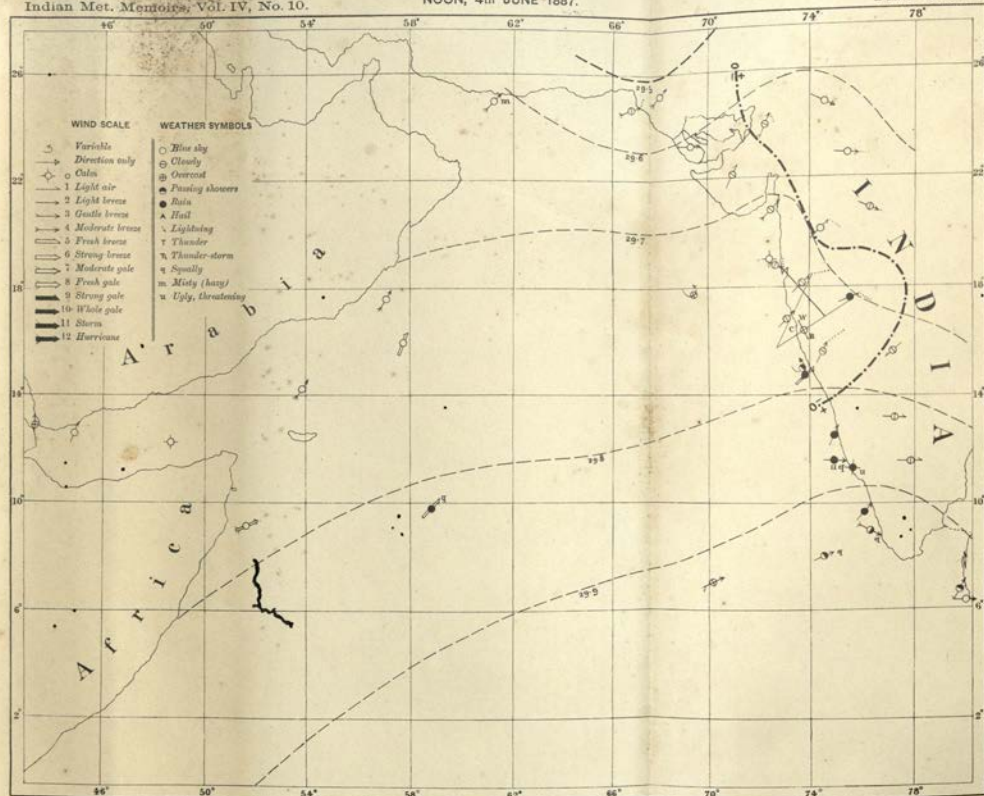
1887. June.	Wind compo- nent direction.	Jacobabad.	Hydrabad.	Karnabec.	Deza.	Bhu.	Ind. N.	Abala.	Makgusa.	Bombay.	Poon.	Sholapur.	Kataguli.	Bilgaum.
Date.														
8	N.	- 7.5	+ 4.2	+ 43.2	+ 6.0	+ 10.9	+ 4.9	- 13.4	- 10.4	- 17.2	- 0.9	- 11.2	...	- 17.2
	E.	+ 8.2	+ 19.3	+ 12.7	+ 24.2	+ 29.4	+ 15.1	+ 16.2	+ 22.7	+ 31.6	+ 22.5	+ 47.4	...	+ 34.4
9	N.	+ 0.5	+ 10.4	+ 13.2	+ 0.4	- 7.8	- 3.4	- 14.8	- 3.9	- 14.7	+ 2.0	- 6.2	+ 2.6	- 11.9
	E.	+ 2.9	+ 40.9	+ 35.7	+ 12.4	+ 32.4	+ 5.2	+ 7.1	+ 7.0	+ 28.8	+ 11.2	+ 3.4	+ 15.9	+ 2.9
10	N.	- 13.3	+ 7.0	+ 5.8	- 8.4	- 11.3	- 4.1	+ 5.5	- 9.0	- 30.6	- 6.5	- 6.6	+ 0.2	+ 5.4
	E.	+ 4.8	+ 2.3	+ 28.1	+ 8.6	+ 25.6	+ 4.5	+ 2.2	+ 5.7	+ 9.0	+ 2.7	+ 2.5	+ 13.1	+ 5.6
11	N.	- 14.2	+ 5.6	+ 2.6	- 7.0	- 9.4	+ 0.8	- 3.0	- 16.9	+ 16.5	+ 6.2	+ 14.6	- 3.9	+ 3.9
	E.	- 8.6	+ 0.9	+ 14.1	+ 15.5	+ 24.8	- 2.6	+ 10.7	+ 7.0	+ 4.4	- 2.6	+ 6.7	+ 3.6	- 14.2
12	N.	- 2.5	+ 1.2	- 0.9	- 9.4	+ 0.6	+ 0.8	+ 15.2	- 1.2	+ 5.0	+ 6.2	+ 4.5	...	+ 3.2
	E.	+ 3.2	+ 4.0	+ 10.6	+ 8.6	+ 4.4	- 2.6	+ 4.4	- 8.5	- 2.0	- 12.6	+ 2.1	...	- 16.3
13	N.	- 7.5	+ 4.2	+ 4.8	+ 8.1	- 9.4	+ 15.6	+ 4.1	- 1.2	+ 5.4	+ 1.2	+ 5.3	...	+ 10.1
	E.	- 6.6	- 0.5	+ 4.4	+ 4.9	+ 11.8	+ 3.3	- 9.4	- 4.5	- 3.0	+ 3.3	- 4.0	...	+ 8.7
14	N.	- 6.8	+ 1.6	+ 6.2	+ 9.6	+ 8.2	+ 13.7	+ 2.6	- 1.2	- 0.3	+ 0.8	- 2.9	...	- 14.7
	E.	+ 4.3	+ 2.9	+ 3.5	+ 9.6	+ 13.7	+ 4.0	- 5.7	+ 5.5	+ 3.3	+ 2.5	- 0.3	...	+ 1.8

WEATHER CHART OF THE ARABIAN SEA.

Indian Met. Memoirs, Vol. IV, No. 10.

NOON, 4th JUNE 1887.

Plate XLIV.

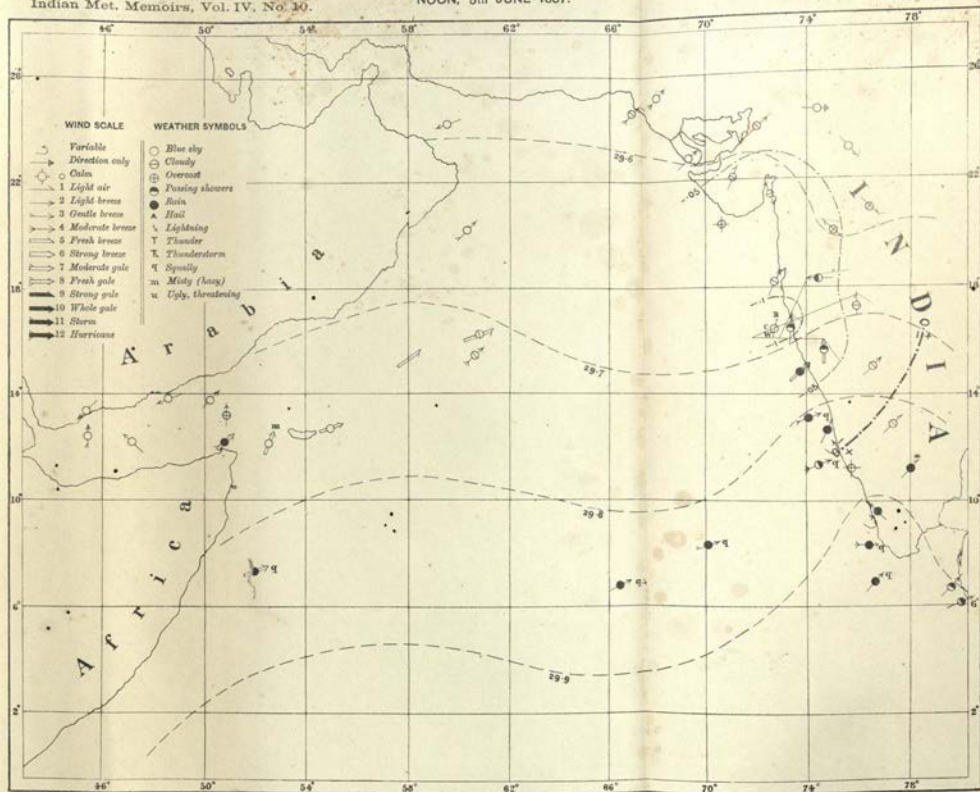


WEATHER CHART OF THE ARABIAN SEA.

NOON, 5th JUNE 1887.

Plate XLV.

Indian Met. Memoirs, Vol. IV, No. 10.

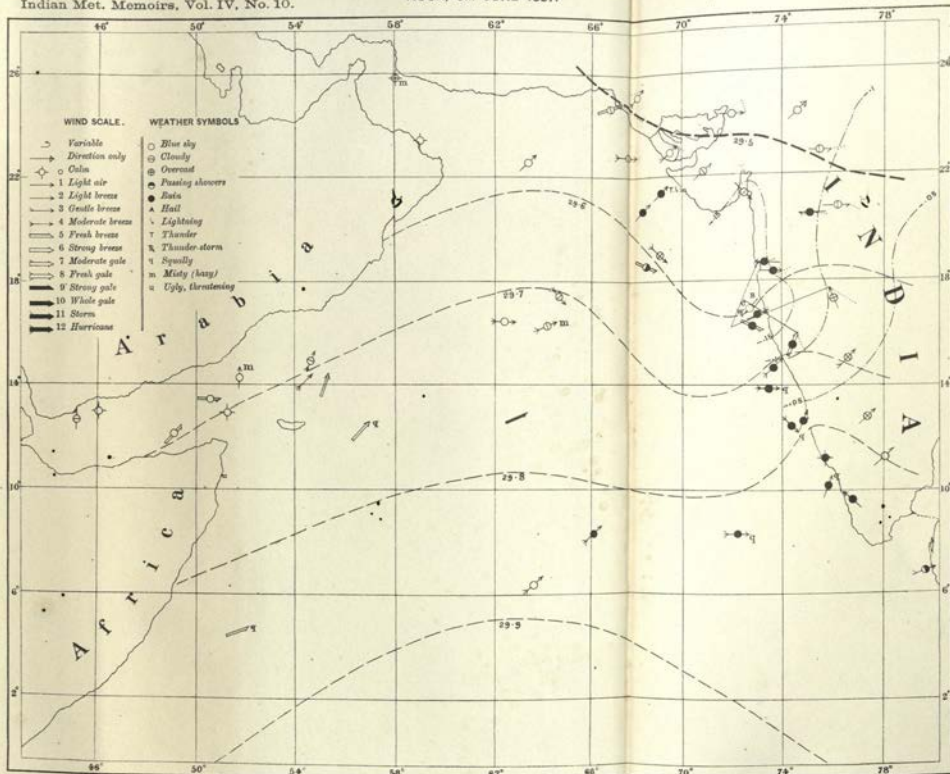


WEATHER CHART OF THE ARABIAN SEA.

NOON, 6th JUNE 1887.

Plate XLVI.

Indian Met. Memoirs, Vol. IV, No. 10.

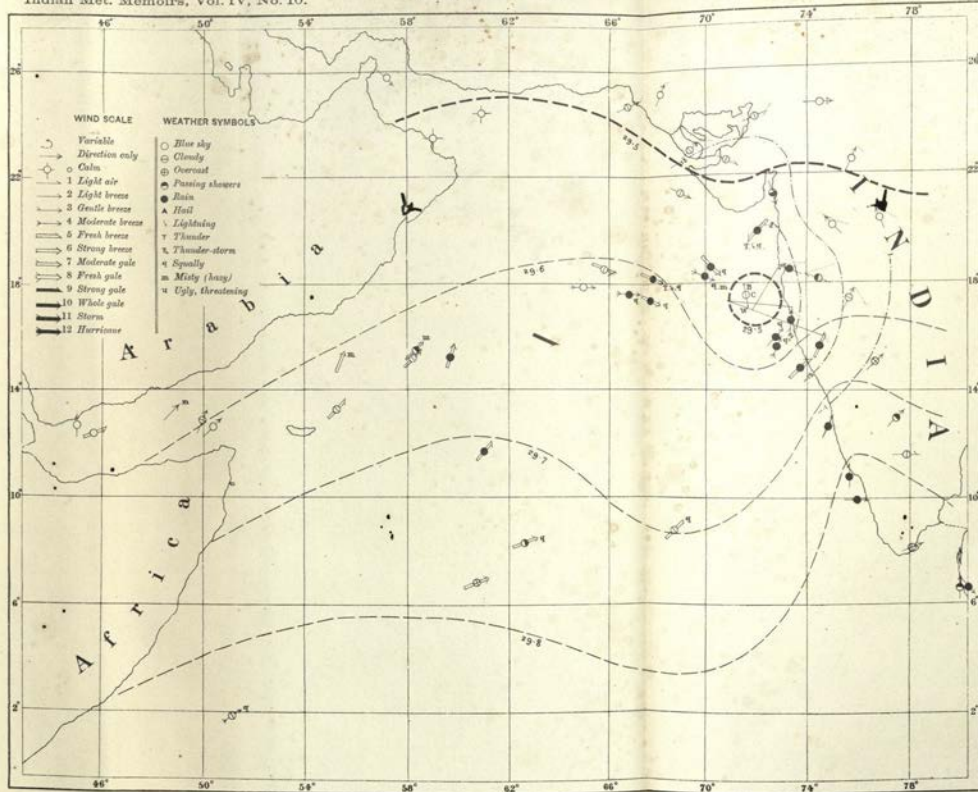


WEATHER CHART OF THE ARABIAN SEA.

NOON, 7th JUNE 1887.

Plate XLVII.

Indian Met. Memoirs, Vol. IV, No. 10.

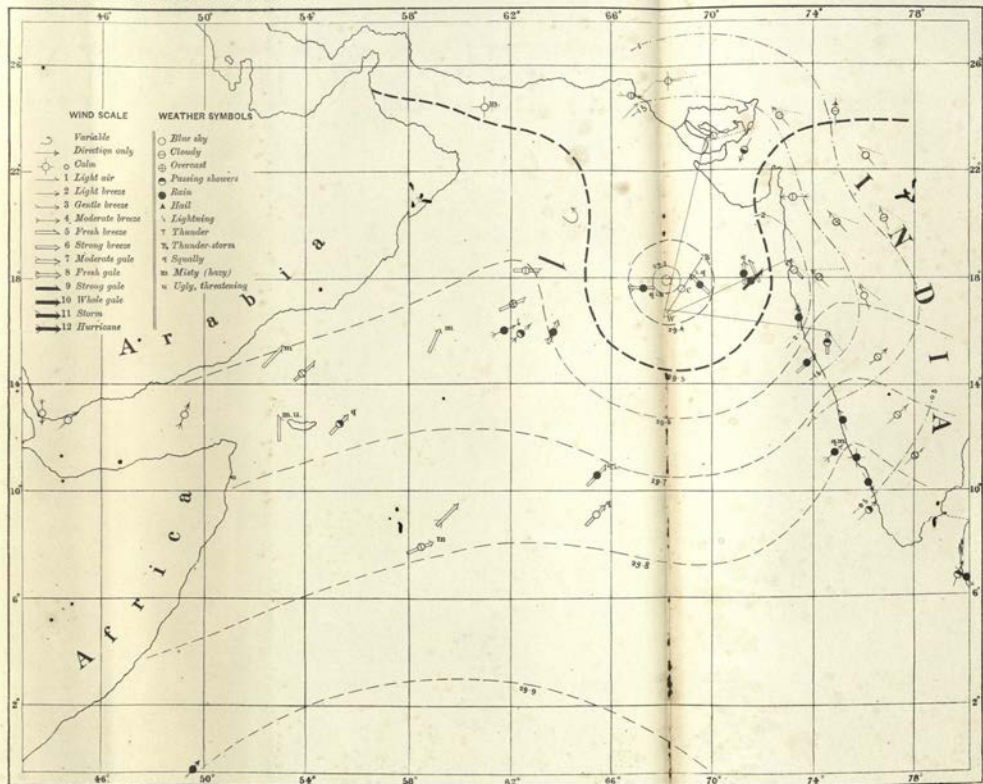


WEATHER CHART OF THE ARABIAN SEA.

Indian Met. Memoirs, Vol. IV, No. 10.

NOON, 8th JUNE 1887.

Plate XLVIII.

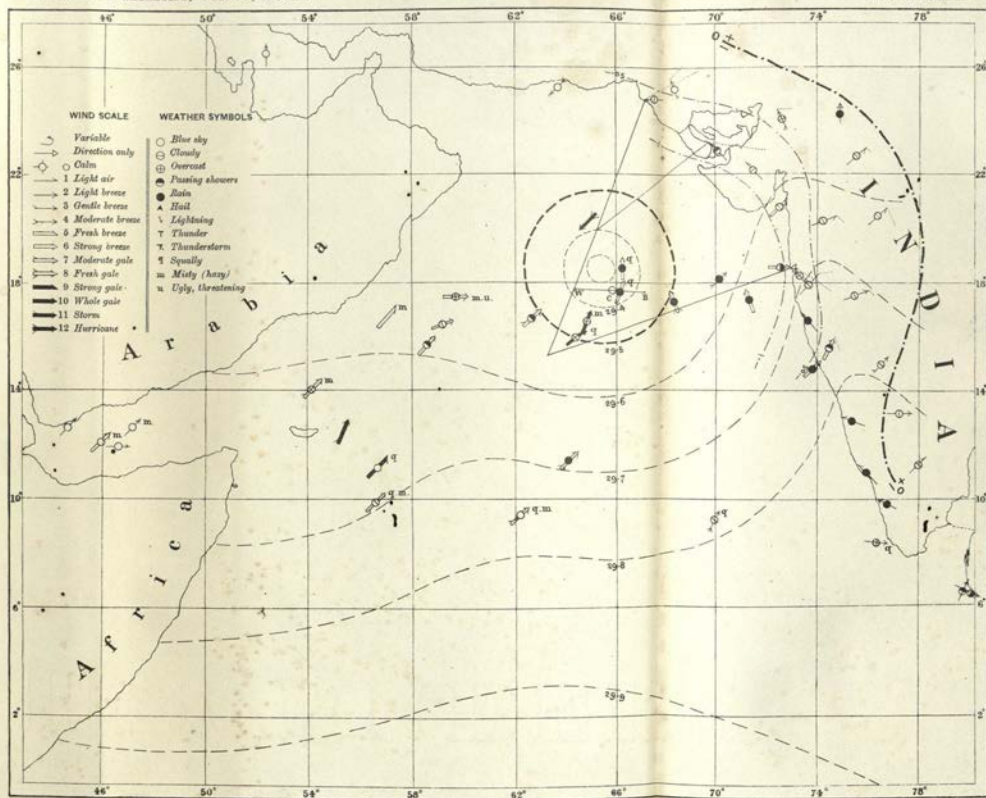


WEATHER CHART OF THE ARABIAN SEA.

Indian Met. Memoirs, Vol. IV, No. 10.

NOON, 9th JUNE 1887.

Plate XLIX.

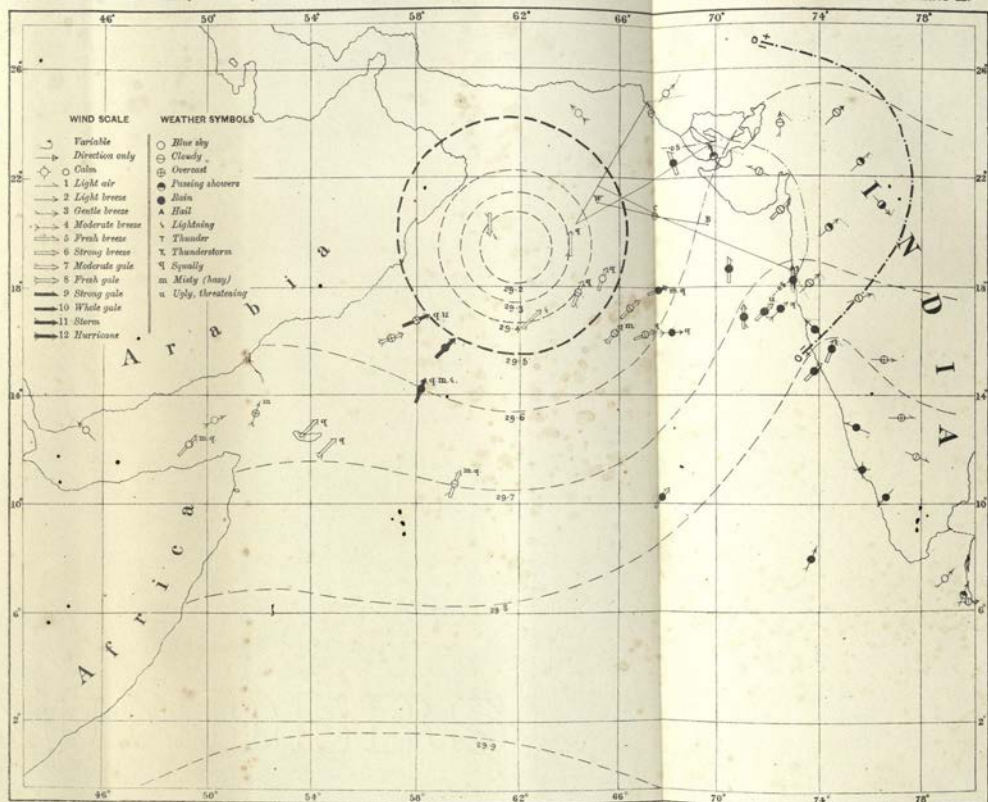


WEATHER CHART OF THE ARABIAN SEA.

NOON, 10th JUNE 1887.

Indian Met. Memoirs, Vol. IV, No. 10.

Plate L.

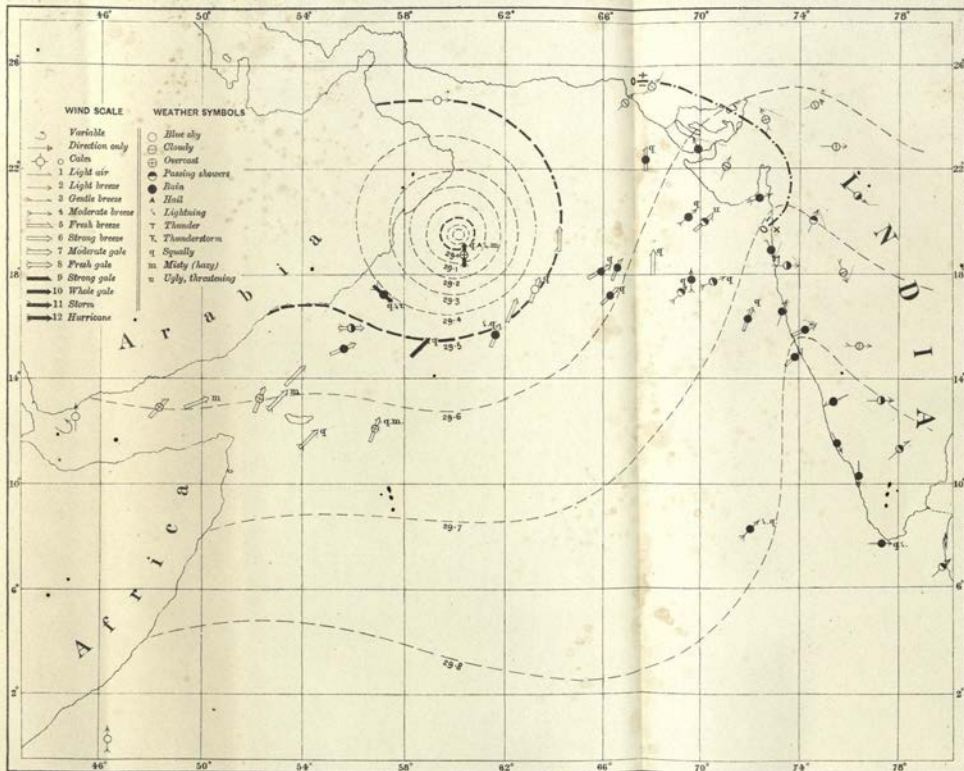


WEATHER CHART OF THE ARABIAN SEA.

Indian Met. Memoirs, Vol. IV, No. 10.

NOON, 11th JUNE 1887.

Plate LI.

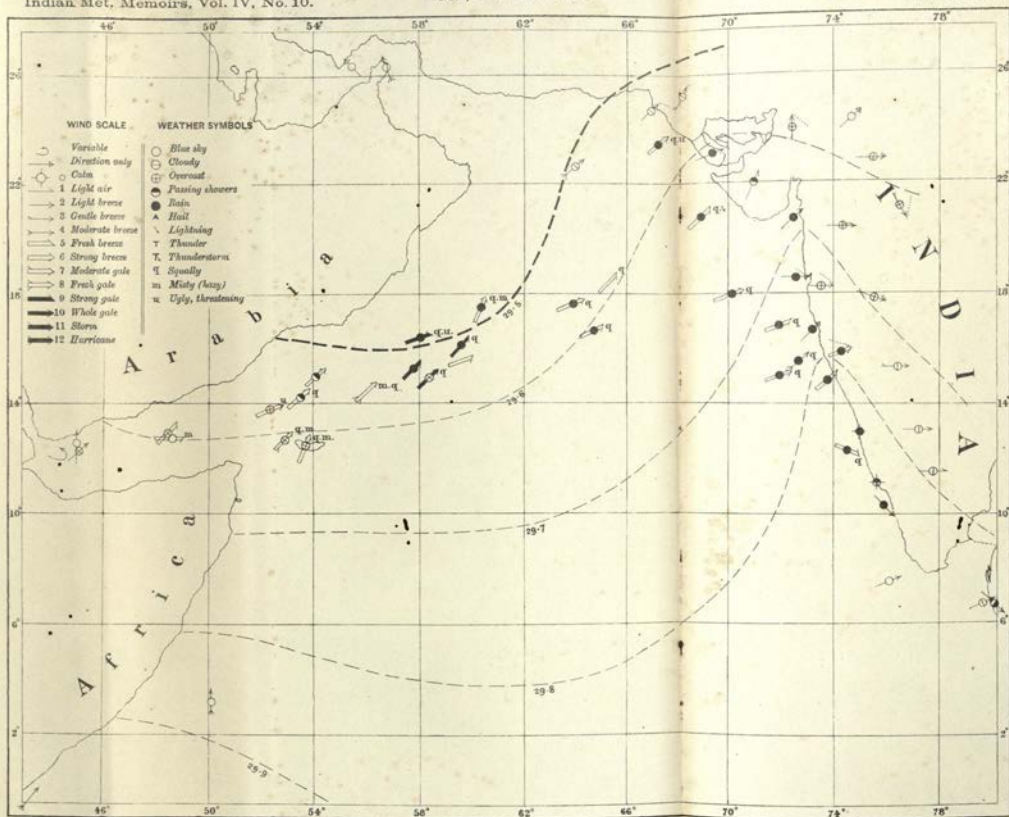


WEATHER CHART OF THE ARABIAN SEA.

Indian Met. Memoirs, Vol. IV, No. 10.

NOON, 12th JUNE 1887.

Plate LII.

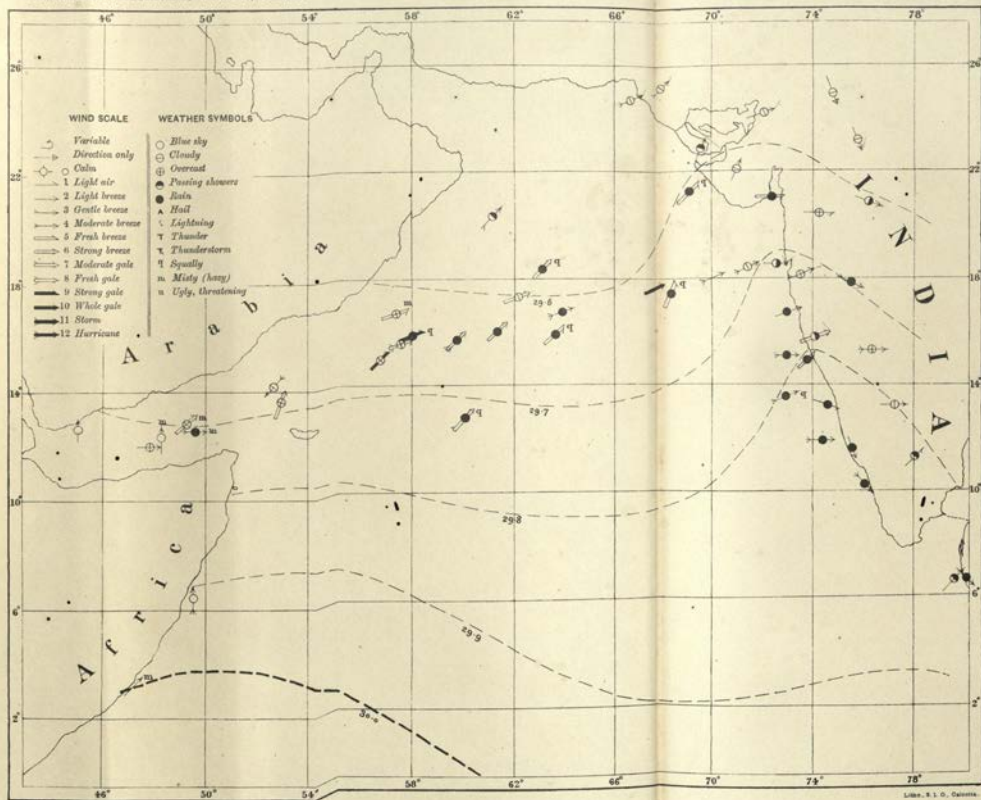


WEATHER CHART OF THE ARABIAN SEA.

NOON, 13th JUNE 1887.

Plate LIII.

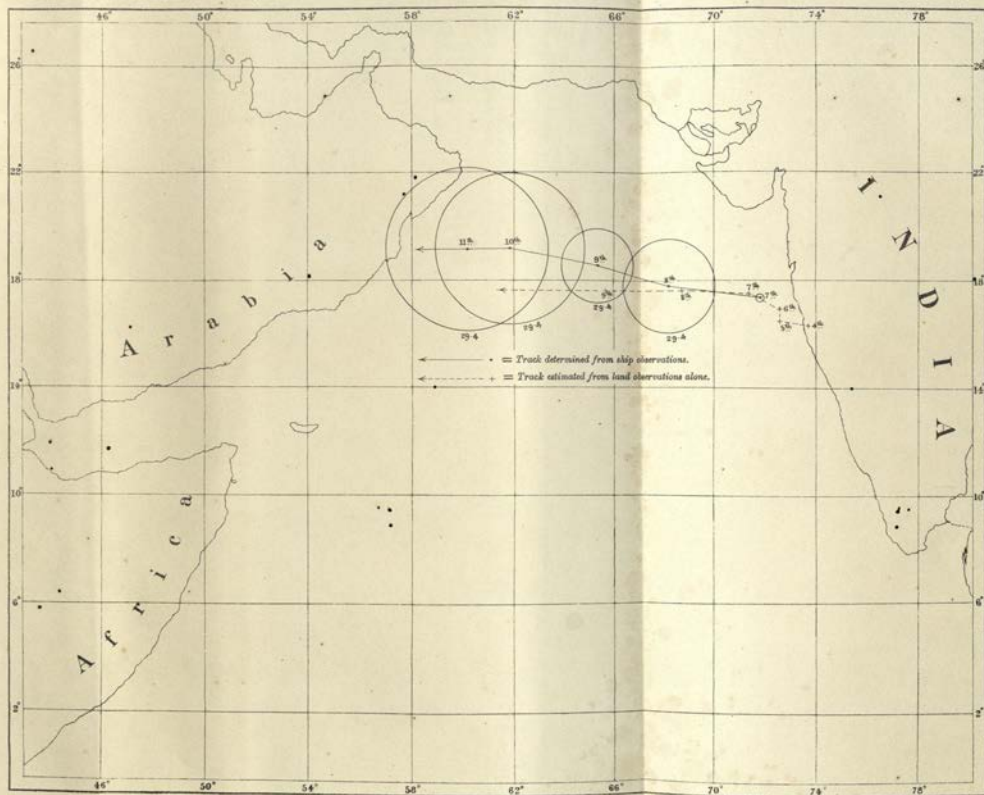
Indian Met. Memoirs, Vol. IV, No. 10.

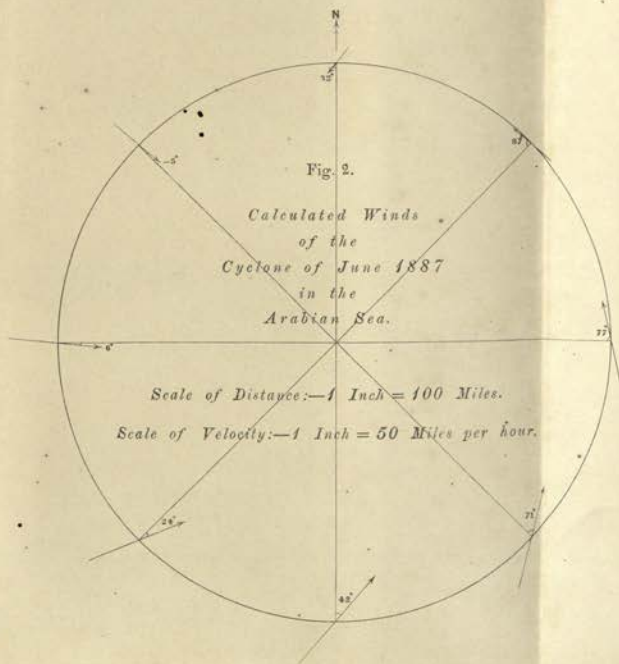
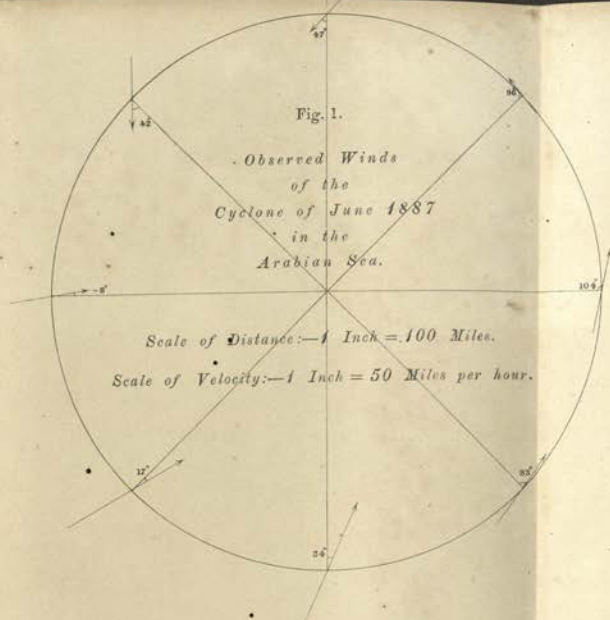


TRACK OF THE CYCLONE OF THE 4th TO THE 12th OF JUNE 1887.

Indian Met. Memoirs, Vol. IV, No. 10.

Plate LIV.





*XI.—On the Meteorology and Climatology of Northern Afghanistan, by W. L. DALLAS,
Assistant Meteorological Reporter to the Government of India.*

The meteorology of Afghanistan is of interest in India, as it is unquestionable that, weather changes have at different times passed from that country into North-Western India, while the climatology may at any time suddenly leap into importance owing to the necessity of conducting military operations within that country. Hitherto this region has been practically closed to scientific investigation of almost every description, so that the presence of a scientific body, such as accompanied the Afghan Delimitation Commission, was eagerly utilized to supply as far as possible the deficient information. The meteorological and climatological work was carried on by three different officers, *viz.*, Colonel Maitland, Assistant Quarter Master General, Intelligence Branch, Surgeon-Major Owen, of the Indian Medical Service, and Captain St. G. Gore, R.E., of the Survey Department. The records of these three officers differ widely in character. Dr. Owen had the most complete equipment of meteorological instruments, and recorded his observations according to the forms employed in the Indian Meteorological Department, so that most of the mean readings contained in the following pages, have been obtained from his observations. In addition to this, Dr. Owen being attached to the head-quarters of the Commission, his halts were longer and his observations less fragmentary than those of the other officers. Colonel Maitland's movements were almost constant during the periods intervening between the coldest and hottest portions of the year, and his information is consequently rather descriptive than instrumental, as, owing to his constant changes in elevation, his records of temperature and pressure can seldom be combined so as to give averages which would afford guides as to the exact character of the weather over any large tract of country. Captain Gore's observations are, in the majority of cases, the record of the pressure and temperature at the stated hours of 10 A.M. and 4 P.M. They consequently give a certain amount of information as to the diurnal range of pressure, but afford little as to the extremes of temperature which, for climatological purposes, is so important.

The observations extend over a period of two years, from October 1884 to October 1886. During this period there were a few halts of over a month's duration when very fairly accurate means are obtainable, but during the greater part of the period the Commission was moving from day to day, and the observations are consequently fragmentary, the morning and evening observations frequently referring to different places. This occasions a certain amount of uncertainty as to the value of the average data, but it is probable that the general result is not far from the truth, the variations caused by movement in one direction at one time being in all likelihood compensated for by a movement in a contrary direction at another.

The general directions of the marches of the different officers, from whose observations the means have been obtained, are given roughly in the following paragraph.

The observations were commenced on the Helmand River at Khwaja Ali, and were continued along the valley of that river, the Sistan basin, and thence northward to the Herat Valley. At Kuhsan, on the Hari Rud, there was a halt for some days. The party then proceeded north-eastward to *Bala Murghab*, where observations were recorded from the 12th

December 1884 to the 14th of February 1885. A small portion of the Commission then followed the Murghab River, and recorded observations at *Panjdeh* from the *23rd of February to the 28th March*. Then occurred what is known as the Panjdeh incident and scientific researches gave way to more exciting events. On April 21st observations were resumed at *Tir-pul* (close to Kuhsan). A halt occurred here from *April 21st to 17th May*. The next halts of any consequence were at *Sinjao*, to the north-west of Herat, lasting from *May 24th to June 11th*, and at *Kushk*, lasting from *20th to 25th June*. The next movement was southward to the Hari Rud again, and the next halts of importance were at *Zindajan* from *July 31st to 13th August*, at *Sangbast* from *August 14th to September 2nd*, and at *Ulangi Afghan* from *September 3rd to September 21st*. In October, observations were recorded during a rapid journey to and from *Mashhad*. The next long halt was at *Zul-fikar*, lasting from *10th to 26th November*, and the next at *Hauzi-Khan* from *December 3rd to December 14th*. From *18th to 29th December, 1885*, the observations were taken at *Maruchuk*, and from *8th January to March 24th, 1886*, at *Chahar Shamba*, on a branch of the Murghab River, in Long. 64° E. and Lat. $35^{\circ} 45'$ N. On the 25th a party travelled westward to *Karawal Khana*, and observations were recorded there from *March 26th to April 19th*; at *Chahar Shamba* from *April 24th to May 6th*, and at *Andkui* from *May 19th to May 23rd*. On 28th May the Oxus was reached, and a halt occurred at *Kham-i-Ab* in Long. $65^{\circ} 50'$ E. and Lat. $37^{\circ} 30'$ N. from *May 28th to July 22nd*. The next long halt was at *Shadian* to the south-east of Mazar-i-Sharif, and lasted from *27th July to 28th August*, after which observations were resumed at *Kham-i-Ab* from *September 5th to September 14th*. The concluding observations were recorded during a journey east-south-eastward to Haibuk, and south-eastward to *Kabul* (*October 15th to 23rd*).

The following table gives the average temperatures recorded during this journey. The means are obtained in most instances from 3 observations a day, *viz.*, the readings of the minimum thermometer, and the 10 A.M. and 4 P.M. temperatures, and have been corrected by a factor to bring them to the true mean. The instances in which the whole of these observations were not available have been noted in the table. The exact means have in all cases been given, and where any alteration in these means seems required by the circumstances of the case, the precise alteration and the reasons have been stated.

Month.	YEAR.		
	1884.	1885.	1886.
	°	°	°
January	...	32.4	35.4
February	...	36.3	27.6
March	...	47.9	47.3
April	...	71.0a	56.6
May	...	77.6a	70.5
June	...	82.7a	82.1
July	...	83.8a	82.4
August	...	81.8	69.6
September	...	70.5	71.1
October	66.1	54.5	58.3
November	48.9	51.8	...
December	40.0	37.8	...

NOTE—(a) Mean of 10 and 16 hours.

Taking these figures in connection with the movements given above, it will be noticed that the first observations were recorded within the Baluch desert, south of the Helmand. Khwaja Ali on the Helmand is in about the same latitude as Multan (October mean 77°), and temperature is high even at the end of October. During the following eight weeks, however, the course of the Commission was nearly due north towards Herat, so that in addition to the fall of temperature due to seasonal change, there was also the fall due to northerly progression, and the change of temperature between October and November is large, amounting to 17° . Early in December the camp was established at Bala Murghab, in Long. $63^{\circ} 20' N.$ and Lat. $35^{\circ} 37' E.$ and the mean temperatures of December 1884, and January and February 1885, may be taken to represent (so far as is possible with only one season's observations) the true mean temperature of that part of Northern Afghanistan. The mean temperature of March may equally be accepted as an approximately true representation, as all the observations were recorded at one station, Panjdeh. For the first three weeks of April there are no observations available, and the mean for this month is obviously too high, first, because the observations only refer to the period April 21st to 30th, and second, because during those three weeks the point of observation was removed 130 miles southward to Tirpul on the Hari Rud. It is necessary, then, in this case to apply some form of correction to the mean reading. In the following year 1886, the mean reading for the whole of April is 56.6° , and the mean for the period 21st to 30th is 63.5° or 6.9° higher. Arguing that the same relation holds good for the period 21st to 30th April 1885 to the whole month, the reading of 71.0° must be reduced by 6.9° and becomes 64.1° . The further decrease due to difference of latitude does not amount to more than one or two-tenths, so that it may be disregarded. During the months of April, May, June and July, however, the readings 64.1° , 77.6° , 82.7° and 83.8° are derived from means of the 10 A.M. and 4 P.M. observations only, and these are of course also too high and must be corrected. At Quetta, in 1886, the mean of the 10-hours and 16-hours observations is:—

11.8°	higher than the true mean for April.
12.6°	” ” ” ” May.
11.8°	” ” ” ” June.
8.6°	” ” ” ” July.

Applying these corrections to the readings given above, the values for the different months become:—

April	.	.	.	.	.	.	.	$64.1^{\circ} - 11.8^{\circ} = 52.3^{\circ}$
May	.	.	.	.	.	.	.	$77.6^{\circ} - 12.6^{\circ} = 65.0^{\circ}$
June	.	.	.	.	.	.	.	$82.7^{\circ} - 11.8^{\circ} = 70.9^{\circ}$
July	.	.	.	.	.	.	.	$83.8^{\circ} - 8.6^{\circ} = 75.2^{\circ}$

The observations for August 1885 were all recorded at the two stations of Zindijan and Sangbast, both stations in the Hari Rud Valley, and close to the important centre of Herat; they may be accepted as showing fairly truly the temperature of this region

at this season of the year. During September the observations were recorded during a journey west-north-westward up the valley of the Hari Rud, but the marches were slow, and the mean of the temperature observations (*viz.* $70^{\circ}5'$) of the month represents the mean temperature of the Hari Rud Valley between Kuhsan and Herat. During October a rapid march north-westward to Mashhad and back to Herat was made, and the mean value for October represents the temperatures recorded during those marches. The major part of November was spent at Zulfikar, also on the Hari Rud, but 100 miles north-west of Herat. This position probably accounts for the small difference which is shown between the means of October and November. In December the observations were recorded partly at Hauz-i-Khan in Badghis, at Maruchak on the Murghab River between Karawal Khana and Panjdeh, both places in the watershed of the Murghab River, and partly in the Murghab country to the north-west of the Band-i-Turkistan range of hills. The mean temperature was $37^{\circ}8'$, which was 2° lower than the mean of Bala Murghab, though all three places are within a few marches of each other. In January 1886, the Commission settled down at Chahar-Shamba, and the mean temperatures of January, February and March were recorded at this station. The very low temperatures in February, and the large contrast between February and March, are the result of carefully observed temperatures in one spot and may be safely relied on. In April the Commission was again close to Bala Murghab at Karawal Khana, and the mean temperature for April was recorded at that station. The station is somewhat lower (1,300 feet) than Charhar-Shamba, and the larger rise between March and April of the present, as compared with the previous year, is probably partly due to this change of elevation. May was passed moving about on the low plain near the Oxus and the temperature was high. During the whole of June, and the greater part of July, the Commission was camped on the bank of the Oxus at Kham-i-Ab at a height of 909 feet above mean sea-level and the heat was great throughout. At the end of July the officer recording the observations moved up to Shadian to the south-east of Mazár-i-Sharif, and at a height of 5,700 feet above mean sea-level. There is consequently a sudden fall of temperature to $69^{\circ}6'$, and this, to make it at all comparable with the mean of the preceding month, must be corrected for elevation. The height of Kham-i-Ab camp being 909 feet, and that of Shadian 5,700 feet, the difference is 4,800 feet; and taking Murree and Rawalpindi as being the nearest places where investigations into the vertical change of temperature have been attempted, we find that a change of 1° corresponds to a change of elevation of 326 feet; dividing 4,800 by 326, we obtain $14^{\circ}7'$ as the addition, which has to be applied to bring the readings recorded at Shadian to a fair comparison with those recorded at Kham-i-Ab. Thus the temperature of August becomes $84^{\circ}3'$, and August, as in the preceding year, becomes the hottest month of the year.

In September the officer keeping the meteorological record returned to the Oxus plains and continued there for the greater part of the month, but after the 25th the observations were recorded among the highlands lying to the south-east of Mazár-i-Sharif, and the low temperatures recorded there result in a rather low mean for the month, there being a difference of 13° between the means of August and September. During October the whole of the Commission advanced southward to Kabul, and thence on to the Indian frontier where the mean temperature was found to be $58^{\circ}3'$.

The observations thus corrected become :—

MONTH.	YEAR.		
	1884.	1885.	1886.
January . . . . .	....	32'4	35'4
February . . . . .	.....	36'3	27'6
March . . . . .	.....	47'9	47'3
April . . . . .	.....	52'3	56'6
May . . . . .	.....	65'0	70'5
June . . . . .	.....	70'9	82'1
July . . . . .	.....	75'2	82'4
August . . . . .	.....	81'8	84'3
September . . . . .	.....	70'5	71'1
October	66'1	54'5	58'3
November	48'9	51'8	.....
December	40'0	37'8	.....

Before proceeding further, it would perhaps be desirable to show roughly the amount of trust to be placed in these observations by comparing them with the means of the same period at Quetta and Peshawar.

Comparing each month's mean with the annual average obtained from the two years' observations for the three places the following differences are obtained :—

MONTH.	YEAR.								
	1884.			1885.			1886.		
	Afghanis- tan.	Quetta.	Peshawar.	Afghanis- tan.	Quetta.	Peshawar.	Afghanis- tan.	Quetta.	Peshawar.
January	...	...	...	-25'4	-19'7	-21'1	-22'4	-19'7	-19'7
February	...	...	...	-21'5	-19'5	-20'0	-30'2	-19'2	-19'9
March	...	...	...	-9'9	-6'3	-7'1	-10'5	-8'9	-8'2
April	...	...	...	-4'7	-3'6	-3'3	-1'2	+1'7	-0'6
May	...	...	...	+7'2	+1'8	+1'2	+12'7	+10'1	+12'5
June	...	...	...	+13'1	+15'0	+16'4	+24'3	+18'1	+19'9
July	...	...	...	+17'4	+20'7	+19'5	+24'6	+22'6	+21'8
August	...	...	...	+24'0	+19'2	+18'6	+26'5	+19'6	+18'6
September	...	...	...	+12'7	+10'2	+11'1	+13'3	+12'2	+13'5
October	+8'3	-2'5	-0'8	-3'3	-0'9	+1'9	+0'5	-0'6	+3'6
November	-8'9	-12'1	-13'6	-6'0	-6'4	-8'0	...	...	...
December	-17'8	-15'0	-19'6	-20'0	-15'8	-17'1	...	...	...

These comparisons show a general agreement, and it may be assumed that in the majority of cases the means of the various months give a fairly correct representation of the temperature of Afghanistan. The two means about which there is any considerable

doubt are October 1884 and June 1886. The former average is derived from readings recorded along the banks of the Helmand in Lat. $30^{\circ}10'$ N. and is obviously not comparable with a general average derived from observations read from 5° to 8° further northward, while the mean for June 1886 is derived from observations all recorded at Kham-i-Ab, a township on the bank of the Oxus only 909 feet above mean sea-level, and evidently enjoying a climate much hotter than that in more open regions. The large departure in February 1886 appears to be correct, and its cause will be referred to later on.

Having thus tested the general creditability of individual means, they may now be combined to find the normal monthly and annual averages.

Combining the corrected readings to find the mean annual and monthly temperatures for the north of Afghanistan, the following table is formed:—

DATE.	Year.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Mean.
Mean temperatures of the different months	1884	...	...	...	...	...	...	...	...	...	66.1	48.9	40.0	
	1885	32.4	36.3	47.9	52.3	65.0	70.9	75.2	81.8	70.5	54.5	51.8	37.8	
	1886	35.4	27.6	47.3	56.6	70.5	82.1	82.4	84.3	71.1	58.3	...	...	
Sums	...	67.8	63.9	95.2	108.9	135.3	153.0	157.6	166.1	141.6	178.9	100.7	77.8	
Means	...	33.9	31.95	47.6	54.45	67.75	76.5	78.8	83.05	70.8	59.6	50.35	38.9	57.8

The general mean temperature of Afghanistan for the year is thus 57.8° , which is 1.0° higher than the annual mean at Quetta. The latter station is, however, 5,504 feet above mean sea-level, while the mean height of the different places of observation in Afghanistan would be approximately 2,490 feet. This would give a difference of 3,014 feet which, accepting Rawalpindi and Murree, as before as giving the vertical decrement of temperature would necessitate an addition of 6.1° to the Quetta mean to make the two comparable. There is thus a fall of 5.1° in temperature between the north of Baluchistan and the north of Afghanistan. Taking Bala Murghab as the point around which the observations centred the above gives a difference of 6.1° for $5^{\circ}25'$ of latitude.

The theoretical averages of the mean temperatures of all longitudes for the parallels of 30° and 40° North Lat. are 68.72 and 57.92 , respectively, giving a difference of 10.80 for the 10° of Lat. or 5.8 for $5^{\circ}25'$ of Lat. The theoretical and observed differences thus agree very closely.

The annual march of temperature shows certain differences when compared with the march of the same element in Northern India. The minimum occurs in February, and the maximum in August; the former peculiarity is attributable in the present series of observations to the remarkably low temperature experienced in February 1886, when the mean was only 27.6 , but the probability that on the average this month is colder than January receives confirmation from an inspection of the monthly means of temperature at Quetta, where the February average for nine years is a trifle below that of January. The annual maximum in August is not however borne out by the Quetta curve of temperature the hottest month at that station, as at Peshawar, being July. There appears, however, to be a tendency to throw the maximum later, on advancing westward out of the region of the south-west monsoon, as at Bushire in the Persian Gulf the hottest month is also August.

The curve of temperature derived from the monthly means computed by the formula given by Ferrel,

$$A_e = \sum M_e \cos. \theta_e + \sum N_e \sin \theta_e,$$

- differs in some important respects from the curve of the original figures, the most important change being the throwing of the minimum monthly temperature back to January. The following table shows these differences:—

	January.	February.	March	April.	May.	June.	July.	August.	September.	October.	November.	December.
Original	33'9	31'95	47'6	54'45	67'75	76'5	78'8	83'05	70'8	59'6	50'35	38'9
Computed	31'63	34'52	45'30	56'41	67'31	75'34	80'27	81'29	72'30	58'89	50'0	40'35

These two series of observations plotted, give fairly symmetrical curves, the computed series being naturally slightly more regular than the original. In the computed the drop in February disappears, while the mean temperatures of July and August closely approximate. The rise of temperature between January and August is slower than the fall between August and December, when the weather cools down very rapidly. The thermometer marks above the mean from the middle of April to the middle of October, and below the mean from the middle of October through January to the middle of April.

Extremes of temperature.—With the exception of a few months of 1885 the records of the maximum and minimum temperatures are fairly complete.* During April, May, June and July 1885, the only observations taken at head-quarters were those at the stated hours of 10 A.M. and 4 P.M., but for all the other months the usual record of maximum and minimum is obtainable. Interpolation in the case of extremes of temperature is much more difficult than in the case of mean temperatures, and the existing broken and imperfect series can only be taken as representing the best available, although by no means thoroughly trustworthy information. The following table shows the mean maximum and minimum temperatures and the mean range for the various months irrespective of the altitudes at which the observations were recorded—

MONTH.	1884			1885			1886		
	Mean maximum.	Mean minimum.	Mean range.	Mean maximum.	Mean minimum.	Mean range.	Mean maximum.	Mean minimum.	Mean range.
January	...	...	...	40'7	27'4	13'3	43'5	28'7	14'8
February	...	...	...	46'8	28'7	18'1	38'1	17'2	20'9
March	...	...	...	63'5	37'5	26'0	57'4	35'2	22'2
April	...	...	...	?	?	?	68'6	44'3	24'3
May	...	...	...	?	?	?	84'5	52'7	31'8
June	...	...	...	?	?	?	99'0	63'8	35'2
July	...	...	...	?	?	?	98'2	62'4	35'8
August	...	...	...	91'4	65'4	26'0	80'8*	54'1	26'7
September	...	...	...	83'5	51'4	32'1	85'4	51'4	34'0
October	82'6	48'7	33'9	68'7	36'3	32'4	75'4	39'2	36'2
November	65'8	32'3	33'5	64'9	36'7	28'2	...	...	...
December	53'5	30'2	23'3	52'2	24'7	27'5	...	...	...

* Shadian.

Combining the figures given in the above table, the following rough approximations, are obtained—

MONTH.	Mean maximum.	Mean minimum.	Mean range.
January	42°1	28°0	44°1
February	42°5	23°0	19°5
March	60°5	36°4	24°1
April	68°6	44°3	24°3
May	84°5	52°7	31°8
June	99°0	63°8	35°2
July	98°2	62°4	35°8
August*	86°1 100°8	59°8 65°4	35°4
September	84°5	51°4	33°1
October	75°6	40°4	35°2
November	65°4	34°5	30°9
December	50°7	27°5	23°2

* 14°7 added as in dealing with mean temperatures.

This table shows that the mean annual range of temperature is $100^{\circ}8 - 23^{\circ}0 = 77^{\circ}8$. This inequality agrees closely with the theoretical inequality calculated by Ferrel which for Lat. 36° N and Long. 67° E is $26^{\circ}\text{C} = 79^{\circ}\text{F}$. But though the annual inequality appears theoretically correct, it is much less than that at several stations in the North-west of India. For instance, the annual range at Dera Ismail Khan is $89^{\circ}5$, at Multan is $86^{\circ}2$ and at Rawalpindi is $87^{\circ}1$.

The range of the monthly means is $49^{\circ}66$ which compared with the annual range of monthly means at the stations in North-western India quoted above is somewhat high. At Dera Ismail Khan the range of monthly means is $40^{\circ}6$, at Multan $40^{\circ}3$ and at Rawalpindi $40^{\circ}1$. This excess in the range of the monthly means is largely due to the cold of the winter of 1886, which was exceptionally cold all over Northern India, also, but the low readings of which were masked by the longer series of observations available over India.

The mean range of temperature over Afghanistan increases steadily with the temperature. It is least in January and February, moderate in March, April and December, and large during the autumn and summer months. In this progression it probably agrees with the cloud progression, the cloudiest portion of the year being January, February and March, and the least cloudy, July to October.

Diurnal Range.—The material available for the determination of the diurnal range of temperature is meagre. Hourly readings were on no occasion recorded so that the time of the occurrence of the maxima and minima has been roughly estimated. Plotting these extremes at the estimated hour of occurrence, and subsequently adding the mean temperatures at the fixed hours of 10 A.M. and 4 P.M. the four observations have been connected by a free hand curve. The intervening temperatures have subsequently been read off by scale and the results have been treated by the formula.

$$A_0 = \sum M_s \cos \theta_s + \sum N_s \sin \theta_s$$

the values of M and N having been ascertained by the following process—

$$24 \ M_4 \equiv \Sigma_4 a_i$$

$$12 \ M_2 \equiv \left\{ \begin{matrix} a_6 + a_{22} \\ a_{21} - a_9 \end{matrix} \right\} + \left\{ \begin{matrix} a_1 - a_{13} \\ a_{23} - a_{11} \end{matrix} \right\} \cos 15^\circ + \left\{ \begin{matrix} a_2 - a_{14} \\ a_{21} - a_{10} \end{matrix} \right\} \cos 30^\circ \\ + \left\{ \begin{matrix} a_3 - a_{15} \\ a_{21} - a_9 \end{matrix} \right\} \cos 45^\circ + \left\{ \begin{matrix} a_4 - a_{16} \\ a_{20} - a_8 \end{matrix} \right\} \cos 60^\circ + \left\{ \begin{matrix} a_5 - a_{17} \\ a_{13} - a_7 \end{matrix} \right\} \cos 75^\circ$$

$$12 \ N_2 = a_6 + a_{15} + \left\{ \begin{matrix} a_1 - a_{13} \\ a_{11} - a_{23} \end{matrix} \right\} \sin 15^\circ + \left\{ \begin{matrix} a_2 - a_{14} \\ a_{13} - a_{21} \end{matrix} \right\} \sin 30^\circ \\ + \left\{ \begin{matrix} a_3 - a_{15} \\ a_9 - a_{21} \end{matrix} \right\} \sin 45^\circ + \left\{ \begin{matrix} a_4 - a_{16} \\ a_8 - a_{20} \end{matrix} \right\} \sin 60^\circ + \left\{ \begin{matrix} a_5 - a_{17} \\ a_7 - a_{13} \end{matrix} \right\} \sin 75^\circ$$

$$12 \ M_2 \equiv \left\{ \begin{matrix} a_6 + a_4 \\ a_{11} + a_{16} \end{matrix} \right\} + \left\{ \begin{matrix} a_1 - a_7 \\ a_{13} - a_{18} \\ a_{11} - a_{17} \\ a_{23} - a_{10} \end{matrix} \right\} \cos 30^\circ + \left\{ \begin{matrix} a_2 - a_5 \\ a_{14} - a_{20} \\ a_{10} - a_{18} \\ a_{22} - a_{19} \end{matrix} \right\} \cos 60^\circ$$

$$N \equiv \left\{ \begin{matrix} a_2 + a_9 \\ a_{13} - a_{21} \end{matrix} \right\} + \left\{ \begin{matrix} a_1 - a_7 \\ a_{13} - a_{18} \\ a_{17} - a_{11} \\ a_9 - a_{23} \end{matrix} \right\} \sin 30^\circ + \left\{ \begin{matrix} a_2 - a_5 \\ a_{14} - a_{20} \\ a_{16} - a_{19} \\ a_4 - a_{22} \end{matrix} \right\} \sin 60^\circ$$

$$5 \ M' \equiv \left\{ \begin{matrix} a_2 + a_4 \\ a_9 - a_{23} \\ a_{16} - a_{20} \end{matrix} \right\} + \left\{ \begin{matrix} a_1 - a_5 \\ a_9 - a_{13} \\ a_{17} - a_{21} \\ a_7 - a_{11} \\ a_{17} - a_{13} \\ a_{23} - a_9 \end{matrix} \right\} \cos 45^\circ$$

$$N \equiv \left\{ \begin{matrix} a_2 + a_4 \\ a_{18} + a_{24} \\ a_{18} - a_{22} \end{matrix} \right\} + \left\{ \begin{matrix} a_1 - a_5 \\ a_9 - a_{13} \\ a_{13} - a_{23} \\ a_{11} - a_7 \\ a_{13} - a_{15} \\ a_9 - a_{23} \end{matrix} \right\} \sin 45^\circ$$

$$M \equiv \left\{ \begin{matrix} a_6 + a_3 \\ a_4 - a_9 \\ a_{15} - a_{18} \\ a_{11} - a_{21} \end{matrix} \right\} + \left\{ \begin{matrix} a_1 - a_4 \\ a_7 - a_{10} \\ a_{13} - a_{16} \\ a_{19} - a_{22} \\ a_9 - a_5 \\ a_{11} - a_{16} \\ a_{17} - a_{20} \\ a_{23} - a_2 \end{matrix} \right\} \cos 60^\circ$$

$$12 N_4 = \left\{ \begin{array}{l} a_1 - a_4 \\ a_7 - a_{10} \\ a_{13} - a_{16} \\ a_{19} - a_{22} \\ a_5 - a_8 \\ a_{14} - a_{11} \\ a_{20} - a_{17} \\ a_2 - a_{23} \end{array} \right\} \sin 60^\circ$$

This formula gives the figures shown in the following table as the hourly variations of temperature for the various months of the year. The extremes are given in stronger type so that the variations in the time of the occurrence of the maximum and minimum temperatures are accentuated.

Calculated Diurnal Temperatures.

Hour,	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
1	-4.24	-6.14	-7.19	-6.69	-11.93	-14.23	-11.65	-8.45	-8.34	-11.21	-9.77	-5.35	-8.77
2	-4.84	-6.83	-7.95	-8.44	-14.19	-15.63	-15.02	-10.40	-11.81	-13.32	-11.73	-7.00	-10.60
3	-5.52	-8.05	-8.96	-10.38	-15.93	-16.45	-17.19	-12.21	-15.14	-15.01	-13.47	-8.61	-12.24
4	-6.00	-8.08	-9.90	-11.82	-16.47	-16.13	-17.59	-13.72	-17.88	-16.20	-14.68	-10.21	-13.22
5	-6.03	-8.27	-10.02	-11.79	-15.11	-14.06	-16.09	-14.22	-19.06	-16.30	-14.75	-11.45	-13.10
6	-5.52	-7.69	-8.28	-9.81	-11.75	-10.07	-12.93	-12.72	-17.62	-14.49	-13.12	-11.84	-11.32
7	-4.52	-6.13	-5.80	-6.38	-7.04	-4.79	-8.48	-8.74	-13.06	-10.44	-9.67	-11.13	-8.02
8	-3.03	-3.67	-2.09	-2.66	-1.98	+0.75	-3.27	-2.91	-6.15	-4.83	-4.95	-9.42	-3.68
9	-0.92	-0.56	+1.69	+0.45	+2.64	+5.77	+1.96	+3.13	+1.18	+0.88	+0.20	-6.92	-0.79
10	+1.80	+2.88	+5.12	+2.86	+6.60	+10.06	+6.36	+7.64	+6.88	+5.39	+4.97	-3.69	+4.74
11	+4.80	+6.26	+8.13	+5.11	+10.04	+13.75	+9.32	+9.85	+9.93	+8.31	+8.95	+0.33	+7.90
Noon	+7.34	+9.13	+10.65	+7.57	+13.00	+16.72	+10.93	+10.27	+10.79	+10.26	+12.04	+4.95	+10.30
13	+8.65	+10.93	+12.29	+9.88	+15.12	+18.41	+11.83	+10.13	+10.83	+12.05	+14.21	+9.43	+21.98
14	+8.42	+11.24	+12.45	+11.20	+15.87	+18.12	+12.72	+10.26	+11.15	+13.92	+15.24	+12.68	+12.77
15	+6.99	+10.02	+10.88	+10.92	+15.01	+15.72	+13.74	+10.59	+11.90	+15.26	+14.91	+13.85	+12.48
16	+5.16	+7.76	+8.07	+9.28	+12.89	+11.90	+14.30	+10.43	+12.40	+15.23	+13.21	+12.94	+11.13
17	+3.59	+5.22	+5.01	+7.16	+10.17	+7.84	+13.52	+9.21	+11.90	+13.51	+10.50	+10.78	+9.03
18	+2.45	+3.04	+2.57	+5.38	+7.42	+4.40	+11.07	+7.04	+10.29	+10.57	+7.48	+8.47	+6.68
19	+1.46	+1.42	+0.94	+4.07	+4.78	+1.66	+7.44	+4.53	+8.04	+7.25	+4.59	+6.64	+4.40
20	+0.31	+0.13	-0.33	+2.77	+2.06	-0.88	+3.63	+2.23	+5.72	+4.09	+2.01	+5.16	+2.24
21	-1.03	-1.19	-1.79	+0.99	-0.89	-3.73	+0.42	+0.20	+3.49	+1.07	-0.41	+3.52	+0.05
22	-2.30	-2.64	-3.53	-1.20	-3.85	-6.88	-2.20	-1.82	+1.11	-2.07	-2.84	+1.38	-2.24
23	-3.21	-4.96	-5.19	-3.35	-6.87	-9.88	-4.82	-4.02	-1.68	-5.37	-5.29	-1.08	-4.64
Midnight.	-3.78	-5.27	-6.40	-5.44	-9.51	-12.35	-8.00	-6.30	-4.89	-8.54	-7.62	-3.41	-6.79

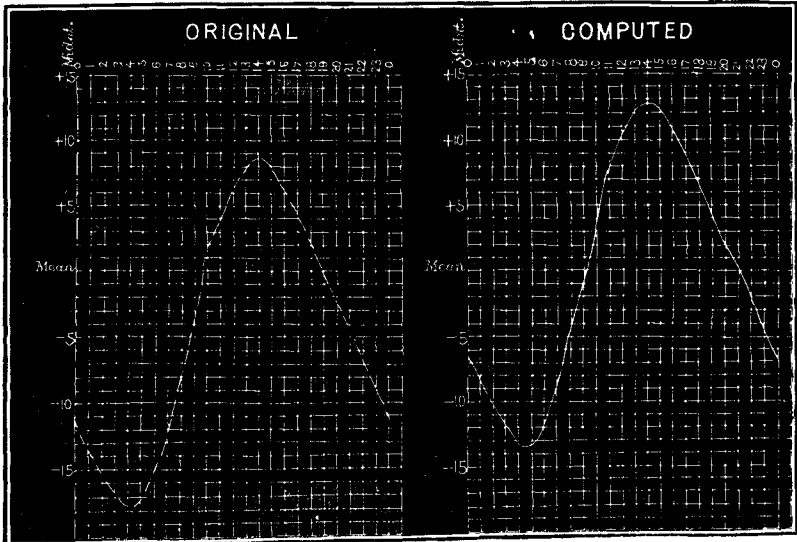
It will be seen that with the exception of June (where there appears to be an inexplicable advance of the hour of maximum temperature) the occurrence of the maximum progresses and regresses fairly regularly. It occurs at one hour after noon in January, two hours after noon in February, March, April and May, four hours after noon in July, and September, three hours after noon in October, two hours after noon in November and three hours again in December.

The minimum occurs at five hours in January, February and March, at four hours in April and May, at three hours in June, at four hours in July, at five hours in August, September, October and November and at six hours in December. The mean diurnal range for each month is as follows:—

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
14°68°	19°51°	22°47°	23°02°	32°34°	34°86°	31°89°	24°81°	31°46°	31°56°	29°99°	25°69°

In this series, August, for the reasons given above, must be regarded as doubtful. Omitting this month, the extent of the daily range shows an increase from January to June from $14\frac{1}{2}^{\circ}$ to nearly 35° . From July to October the range is very uniform, and after October there is a slow fall. The large change which is shown between December and January is probably attributable to the change from dry and fine to damp and stormy weather, which characterises more or less the whole of this part of the continent of Asia. For the mean of the whole year the maximum temperature occurs at 2 P.M. and the minimum at 4 A.M., the amplitude of the mean diurnal range being 26° and the number of hours during which the temperature exceeds the mean being equal to the number of hours during which it is in defect.

Taking the means of the different hours for all months for the original and the computed values the following curves are obtained which exhibit somewhat important variations.



In both the original and the computed observations the minimum occurs at 4 hours and the maximum at 14 hours, but the values of the two extremes exhibit considerable differences, the original figures giving a mean minimum $4^{\circ}34$ and a mean maximum $3^{\circ}90$ lower than those given by the computed figures. Moreover, in the curve of the original figures, the temperature ranges for 15 hours below the mean, and only 9 hours above, instead of presenting the equal excess and defect which characterises the computed curve. On the whole it is more probable that the original values more fairly represent the real diurnal march of temperature than do the computed values. The amplitude of the diurnal range is much the same in both cases.

$$\text{Original} = 26.43^{\circ} \quad \text{Computed} = 25.99^{\circ}.$$

Pressure.—The means of pressure have been obtained in a manner generally similar to that employed for the determination of the means for temperature. The observations for each month have been added together, care being taken to note the altitude at which each observation or each series of observations has been recorded. Subsequently each observation, or series of observations, has been corrected for altitude by the formula given on p. 28 of the Report of the Chief Signal Officer, U. S. A., 1885, Pt. II.

$$\log (\log P' - \log P) = \log (1 - 0.002606 \cos. 2 \lambda) + \log H - 4.780848 \\ - \log [1 + 0.001835 (t' + t)].$$

As the altitudes were constantly changing, sometimes even from day to day, the labour of computing the monthly averages was considerable, and at large elevations the formula apparently gave a correction which was too great. Hence the barometrical readings are not altogether satisfactory, and it is doubtful if they could be safely compared with those recorded within the Indian region. The combined averages for the two years for the various months are—

1885-86.	c	Inches.	V.	V. ₁	V. ₂
January		30.329	+0.292	+0.260	+0.032
February		30.265	+0.228	+0.263	—0.035
March		30.170	+0.133	+0.104	+0.029
April		29.954	—0.083	—0.063	—0.020
May		29.913	—0.124	—0.132	+0.008
June		29.814	—0.223	—0.227	+0.004
July		29.698	—0.339	—0.326	—0.013
August		29.807	—0.230	—0.245	+0.015
September		29.986	—0.051	—0.041	—0.010
October		30.129	+0.092	+0.093	—0.001
November		30.186	+0.149	+0.135	+0.014
December		30.191	+0.154	+0.179	—0.025
Mean		30.037	...	...	...

where the first column of figures gives the mean pressure for the month; V = the variation

of each month's mean from the general mean of the two years; V_1 gives the computed variation by the general formula of reduction and V_2 gives the residuals or the difference between V and V_1 . It will be noticed that in the computed values the maximum pressure of the year occurs in February, while in the original observations it occurs in January. At Quetta for the same two years the maximum mean pressure also occurs in February. The following are the figures giving the values of V for the monthly means of the years 1885-86 for Quetta compared with the general mean for the two years.

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
+0°066	+0°070	+0°031	+0°009	-0°020	-0°134	-0°211	-0°173	-0°075	+0°087	+0°157	+0°112

The amplitude of the oscillation in the case of Quetta is thus $0.368''$, while the amplitude of the oscillation in Afghanistan is as much as $0.589''$. Moreover, in Baluchistan the annual maximum occurs in November with a secondary maximum in February, while in Afghanistan the annual maximum occurs in January with (as shown by V_2) a slight tendency to a secondary maximum in November. In both cases the minimum occurs in July. The fact of the very slight maximum in January and February as compared with that in November and December in Baluchistan, shows that the station of Quetta is under a somewhat different set of meteorological conditions from those prevailing in Afghanistan. Comparing the Afghan anomalies for those two years with the anomalies of Peshawar for the same years a much closer agreement is disclosed.

Peshawar 1885-86 $V =$

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
+0°281	+0°228	+0°124	+0°033	-0°063	-0°324	-0°341	-0°288	-0°102	+0°082	+0°222	+0°272

here the maximum annual pressure occurs in January and the minimum in July, while the amplitude of the annual oscillation is $0.622''$, which is somewhat greater than that in the Afghan series of observations.

The values of V_1 for Peshawar are—

January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.
+0°287	+0°213	+0°100	+0°051	-0°100	-0°315	-0°365	-0°286	-0°130	+0°087	+0°169	+0°250

which are in fairly good accordance with those for Afghanistan and the amplitude of the computed oscillation is $0.652''$.

The observations are so fragmentary and the morning and afternoon observations were so frequently recorded at different stations varying in altitude, geographical position and physiographical surroundings that any attempt to determine the extent and character of the diurnal oscillation of pressure must have ended in failure. That the oscillation was very irregular was evident from a casual inspection of the figures recorded at the few stations where the Commission halted for any considerable time, and in the winter and spring months the ordinary oscillation was at times reversed and the higher

readings were recorded in the afternoon. During the few settled series of observations the range was given as follows :—

Date.	Station.	Range.	Altitude.
1885.			
January	Bala Murghab	0'050"	1,530 feet.
February	Ditto	0'080"	1,530 "
March	Gulran	0'060"	2,460 "
April	Tirpul	0'010"	2,100(?) "
May	Ditto	0'070"	2,100(?) "
June	Sinjao	0'010"	2,830 "
August	Kilki	0'040"	4,524 "
October	Kuhsan	0'090"	2,46 "
1886.			
June	Kham-i-Ab	0'030"	909 "
July	Ditto	0'060"	909 "
August	Ditto	0'060"	909 "
	Mean	0'051"	.....

This Table shows great irregularity in the amount of the daily range the general conclusion being that it is less in the hot than in the cold months of the year. This is in rough agreement with the results obtained at the hill stations in North-Western India. The mean of all the observations is 0'051" which is very much less than the mean diurnal range at Quetta or at the stations in Northern India, but as stated above very little dependence can be placed on the values here given.

Winds.—The two following Tables show the winds prevailing over Afghanistan for the hours of 10 A. M. and 4 P. M. for the different months of the year derived from two years' observations. The principal characteristic is the remarkable uniformity of the resultant direction. Dealing first with the 10 A. M. observations, the column of resultant directions shows that with the exceptions of October and December the resultant direction is from some point between north-west and north-east. The steadiness as estimated by the percentage is small during the winter and spring months from November to April, but is large during the remaining six months from May to October and reaches its maximum in July and August in both of which months the direction is N 18° W. Calms are seldom experienced between March and August, but set in with considerable frequency in the autumn and are common throughout the winter, reaching their maximum in January. The wind force is low, the greatest strength being 3 of the Beaufort scale in August, and its least strength being 0·5 of the Beaufort scale in December.

The 4 P. M. observations show very similar results. The resultant direction throughout the year varies between north-west and north-east. The steadiness of the wind is much greater at the hour of afternoon than at the hour of morning observation, the maximum

steadiness being in May with a secondary maximum in August. The cycle of calms is very plain. In January the number is large, but from this month the record gradually decreases and reaches its minimum in August in which month no instance of calms has been registered. After August the number of observations of calms again increases, and steadily rises to January again. The average force of the wind for the whole year is higher at 4 P.M., than at 10 A.M., though the mean force in August is only 2·5 in the afternoon as compared with 3 in the morning.

The persistency of North (North-West and North-East) winds over this region throughout the year is remarkable. The northing during the summer months is probably due to the influence of the low pressure area over the extreme North-West of India, into which the wind from this quarter probably feeds in an irregular and unsteady manners. In the winter time any movement is very slight, and the fact that the same general direction is maintained as during the summer months is probably attributable to the high pressure area over Baluchistan and Southern Afghanistan mentioned in the author's Winds and Monsoons of the Arabian Sea and Professor Loomis's 22nd Paper.

The following table shows the number of times the wind blew from the different directions at the hour of the morning observation:—

Month.	No. of observations under the different directions at 10 A. M., for the two years.											
	N	NE	E	SE	S	SW	W	NW	Calm.	Resultant Direction.	Force.	Per-centage.
January . . .	9	7	4	...	3	3	7	4	24	N 14° W	1	
February . . .	8	10	5	2	5	4	7	1	10	N 24° E	1	14
March . . .	10	4	8	3	2	2	12	12	6	N 30° W	2	31
April . . .	8	3	4	4	5	2	1	6	4	N 24° E	2·5	15
May . . .	23	8	2	2	3	4	1	6	9	N 2° E	2	44
June . . .	16	5	...	6	2	1	4	17	5	N 20° W	2	47
July . . .	11	9	1	...	...	...	3	21	10	N 18° W	2	62
August . . .	13	15	...	...	2	4	2	25	1	N 18° W	3	62
September . .	9	6	3	2	...	1	2	15	14	N 12° W	1·5	43
October . . .	2	3	8	1	1	1	...	...	15	N 80° E	1·5	33
November . .	3	2	3	2	2	2	...	5	4	N 16° E	1·5	14
December . .	6	3	1	4	5	6	1	2	15	S 16° W	0·5	6

The following table shows the number of times the wind blew from the different directions at the hour of the afternoon observation :—

Month.	Number of observations under the different directions at 4 p. m. for the two years.											
	N	NE	E	SE	S	SW	W	NW	Calm.	Resultant Direction.	Force.	Percentage.
January . . .	8	9	2	1	2	3	5	8	23	N 14° W	1	26
February . . .	11	15	5	1	3	1	6	...	7	N 29° E	1	40
March . . .	9	3	3	2	3	4	11	6	2	N 55° W	2.5	33
April . . .	11	6	4	3	1	3	1	4	7	N 19° E	2.5	34
May . . .	35	12	1	...	2	...	1	8	3	N 3° E	2.5	76
June . . .	21	6	...	5	...	1	5	16	2	N 16° W	2.5	59
July . . .	17	10	1	...	...	...	3	20	8	N 13° W	2.5	67
August . . .	14	17	...	...	...	1	3	25	...	N 12° W	2.5	73
September . .	13	5	4	2	1	...	3	18	6	N 14° W	2	53
October . . .	11	8	10	4	2	1	5	...	9	N 49° E	1.5	34
November . .	9	10	1	2	3	8	2	10	4	N 22° W	1.5	29
December . .	21	2	...	2	6	3	3	7	11	N 22° W	1	35

Comparison of Afghan and Indian weather.

One of the most difficult problems in meteorology and the one which interferes more than any other with an advance towards that successful prediction of weather which is the ultimate aim of the science, is the almost impossible task of discovering the real genesis of the atmospheric changes which affect the weather. It has been a favourite theory with meteorologists in the past to regard India as a self-contained meteorological region cut off from Central Asia, &c., by the high mountains in the north-east, north, and north-west, and from the rest of the world by a belt of calms or doldrums running along the equator from Sumatra to Africa. Such a condition, if it had existed, would probably have rendered the study of Indian meteorology relatively simple and relatively short. Unfortunately it is not an altogether correct view of the situation, and it has become necessary to admit that changes, which, under the former hypothesis, would have been studied as having originated within the Indian region, are really only in process of translation across India, and have had their place of origin in extra-Indian countries. It is obviously misleading to assign to a phenomenon a place of birth which is not its birth place and to study concomitant features as

though they explained a birth when they are really explanatory of a period of growth or decay. Hence although to relegate a storm or a wave of temperature to an origin in Afghanistan, the Caspian or even Europe is a most unsatisfactory and unsatisfying proceeding, it is at least preferable to regarding it as of Indian origin, and to making deductions from antecedent conditions which were very possibly in no way related to the appearance of the phenomenon. The Afghan observations, which we are now studying, apparently show that some of the atmospheric changes which have affected the weather of North-Western India during the two years 1885-86 have had an earlier existence than that indicated by the Indian weather reports.

1885.	Afghanistan.	1885.	North-Western India.
January 5th.	Bala Murghab—Barometer fell $\frac{1}{2}$ inch between 4th and 5th; snowed heavily 5th and 6th; hard frost on 8th.	January 6th to 9th.	Annual Report, 1885.—First rainy period lasted from 6--9th. Last two days rain very general all over Punjab. At Quetta fall equalled 3 inches rain; at Murree $\frac{1}{2}$ feet of snow; a considerable fall of temperature took place.
" 13th.	Bala Murghab—Began to snow again, and on 14th snowed all day.	January 13th.	Another very heavy and general fall of rain and snow occurred on 13th.
February 1st.	Rain or snow occurred off and on till 20th, when weather cleared and was very pleasant.	February.	On North-West Himalaya rain and snow fell almost daily up to 21st.
March 5th.	Gulistan—Snowed heavily last night. Rained all day 6th.	March.	There were showers in the Punjab, on the plains, and at the foot of the hills during the first week.
" 26th.	Snowing this morning; mist rain and sleet all day.	"	Showers in the Punjab and on the hills during the last week of March but middle of month rainless.
" 30th.	Snowing this morning; rain and sleet.		
April 1st to 30th.	Frequent and violent storms of rain. Rain fell on 2nd, 3rd, 4th, 8th, 10th, 11th, 16th, 17th, 22nd, 24th, and 27th.	April 1st to 30th.	On the hills there was no interval of more than two or three days without rain; average was largely exceeded.
October 7th.	Wind violent with rain, on 8th and 9th showery; 10th rain and hail last night; snow on hills; snow fell heavily during the march.	October 11th.	In the Derajat and Hazara there was rain on 11th.
" 16th, and 17th.	Snowed heavily	"	No snow or rain.
November 10th.	Showers and rain; snowed on hills on 11th	"	Absolutely rainless in Punjab.
" 24th.	Snowed all afternoon	"	Do. do.
December 22nd.	Snowed all night and day	"	No snow or rain.
1886.		1886.	
January 1st. and 2nd.	Rain and snow more or less all both days.	January 3rd.	First rainy period was on 3rd and 4th.
" 17th.	Rain after dark; 18th snow and rain; 20th very fine; 21st drizzling wet day, rain afternoon; 22nd rain turned to snow and snowed all day; 23rd stopped snowing this morning.	" 18th.	The third disturbance of the month was more extensive and gave a much larger amount of rain, it commenced on 18th in Punjab, and (with brief interval on 21st) continued till 24th.
" 30th and 31st.	Began to snow about noon; 31st snow lying best part of a foot thick.	February 1st to 30th.	There were four brief periods of rain or snow in Northern India.
" 30th.	A bitter night; thermometer at 11'45' P.M. +6° on 31st at 10'45' A.M. thermometer 8°, very cold, freezing hard; at 11'45' P.M. thermometer 4°, very cold, freezing hard.	"	A cold wave passed from west to east across Northern India. The greatest cold of the year was experienced on the 2nd in Sind Guzerat; 3rd, Punjab, Central India; 4th, North-Western Provinces; Rajputana, Central Provinces; 5th and 6th Bengal and Assam. The preceding shows clearly what is most easily described as a wave of cold.

1885.	Afghanistan.	1885.	North-Western India.
February 1st.	Minimum -12° Very cold. 11 ^h 30' P. M. 16° Cold, air full of little scintillations caused by fall of frozen particles of mois- ture.		
" 2nd	Minimum -11° 10 ^h 45' A. M. 7° 11 ^h 44' P. M. 7°		
" 4th	Snowed all day.	February 5th to 9th.	Disturbed weather, rain and snow.
" 7th	Snowing.		
" 8th to 10th	Very cold; 9th minimum 6° . 10th do. -2° . Maximum 13° .	" 10th and 11th.	Very low minimum temperatures registered North Punjab, and at Jacobabad (11th).
" 14th to 16th	Snowed lightly to heavily, most of this period.	" 15th to 17th	Disturbed period, rain and snow.
" 17th and 18th	Another cold period, minimum 17th 1° . do. 18th 6° .	" 18th and 19th.	Nothing remarkable about the temperatures of North-Western India.
" 25th	Heavy showers during day, rain all after- noon and evening.	" 26th to 28th.	Disturbed period, rain and snow 26th to 28th.
March 1st and 2nd	Rainy period 1st and 2nd, on 3rd weather fine.	March 1st to 3rd.	Fair weather, Northern India.
" 16th and 17th	Disturbed weather Afghanistan, rained and snowed all 16th.	" 17th and 18th.	Disturbed weather Northern India. Dis- turbed period, rain and snow 17th and 18th in Punjab.
" 24th	Thunderstorm 24th, from which date to 29th snow or rain occurred daily.	" 25th	The third period of disturbance in North- ern India lasted from 25th to end of month.
April 7th to 9th.	Heavy storms; rain, snow and thunder from the 7th to 9th.	April 9th	In Lahoul snow fell from 9th to 12th.

This rough comparison leads to the belief that during the winter and more particularly during the spring months, there is considerable connection between the weather of Afghanistan and of North-Western India, and that disturbed periods of weather in Afghanistan are occasionally followed, a day or two later, by similarly disturbed conditions in North-Western India. There are of course several occasions on which snow has occurred in Afghanistan, which have been omitted in the above record. They have been either light or very brief falls, such as would be certain to occur in a mountainous country such as Afghanistan. All the heavier storms have been noticed. It is evident that at times the disturbance which affects the North-West of India is sufficiently extensive to simultaneously affect Afghanistan. Under these circumstances, the changes of weather progress *pari passu* in the two regions. As a rule, however, the changes of weather are one or two days later in India than they are in Afghanistan. A good example of this is given on January 17th, *et seq.*, 1886. Rain commenced in Afghanistan on the 17th, in the Punjab on the 18th; the 20th was fine in Afghanistan, the 21st in the Punjab, snow ceased in Afghanistan on the 23rd, in India on the 24th. The advance of the cold wave over India from the north-west is also very clearly marked. The coldest period in Afghanistan

was the night of the 31st January and 1st February; and the cold wave appeared in North-West India on the 2nd.

Taking the whole of the record into consideration, it may safely be maintained that in the great majority of cases the disturbed weather which appears over North-Western India during the winter and spring months is the result of disturbances, which either affect simultaneously the whole region comprising Afghanistan, Baluchistan and North-Western India, or which have appeared first over Afghanistan and secondly over India, and that these disturbances have seldom originated in India itself or are confined to India.

CLIMATOLOGY.

January.—January 1885 was passed at the camp of Bala Murghab in the Murghab Valley in Lat. $35^{\circ} 33'N$ and Long. $63^{\circ} 30'E$ about 40 or 50 miles from the frontier, and January 1886 at Chahar-Shamba in Lat. $35^{\circ} 50'N$ and Long. $64^{\circ}E$ on a tributary of the Murghab. The two stations are about 30 miles apart, and their climatology gives as accurately as two years' observations can do, the winter conditions of Northern Afghanistan. Snow commenced in the first week of the month, and the temperature at times was very low. At Bala Murghab on the 9th the thermometer marked zero in the early morning, $7^{\circ}5$ at 10 A.M., 21° for the maximum and $17^{\circ}2$ at 4 P.M., but this was an unusually low temperature as the mean extremes for that station, for the whole month were—

Mean Minimum.	Mean Maximum.
27'4	40'7

The highest maximum was $56^{\circ}5$, the lowest 21° , while the lowest minimum was zero and the highest 40° . It is evident, therefore, that the temperature is liable to very sudden and large changes. The following January was less cold, the mean extremes for Chahar-Shamba being—

Mean Minimum.	Mean Maximum.
28°'7	43°'5

The highest maximum was 62° , and the lowest 21° ; while the lowest minimum was 5° and the highest $43^{\circ}5$. On the whole, the two months agree fairly well, and probably represent the temperature-conditions which may fairly be expected in January. It is interesting to note that while the records of the winters of 1885 and of 1886 seem to show that Bala Murghab is colder than Chahar-Shamba the popular belief is that the former place is exceptionally warm and the latter place somewhat exceptionally cold. The weather, as a rule, was dull and cloudy, with only an occasional fine day, and snow or rain was extremely frequent. Occasionally snow was heralded in by thick mist and fog, which subsequently turned to rain, and thereafter to snow, but the remarkable fogs of Badghis, invariably preceded by a large barometric fall did not, as a rule, turn to rain or snow. After two or three days of this weather the wind went round to south and the sky cleared at once. There was ordinarily very little breeze.

The barometer falls quickly before heavy snow. Thus in 1885 the barometer fell $0.11''$ between 10 A.M. and 4 P.M. of the 4th, and $0.42''$ between 4 P.M. of the 4th and 10 A.M. of the 5th, whilst the wind, which had previously been northerly, shifted suddenly to south-south-west just before snow began to fall. These changes apparently precede all heavy falls of snow.

February.—February 1885 was spent between the valley of the Hari Rud and that of the Murghab; that of 1886 was passed entirely at Chahar-Shamba. The temperature remained very low. The minimum thermometer recorded frost almost every night during the first three weeks, and judging from the present series of observations the weather of the early part of this month appears to be more steadily cold than that in January. The mean minimum in 1885 was 28.7° , and the mean maximum 46.8° . In 1886 this cold was more remarkable than in 1885, and the mean minimum was only 17° , and the mean maximum only 38° . Waves of intense cold appear to be frequent during this month. One occurred on the 10th and 11th in 1885, when the thermometer fell to 16° , and a second and very severe one in the commencement of February 1886, when the thermometer fell to -12°F . Towards the close of the month a brisk rise of temperature occurred, and the weather became almost mild. The cold waves noticed above appeared to succeed heavy falls of snow on the hills. The weather was less dull and cloudy than during January, the intervals between the snow storms enjoyed fairly bright weather.

March.—Observations were made during the greater part of March 1885 at the station of Gulran, 2,400 feet high, in the Badghis country to the north of the Herat Valley and at Panjdeh on the northern frontier; while most of March 1886 was passed at Chahar-Shamba and Maruchak. In 1885 the extremes of temperature were as follows:—

Mean Minimum $37^{\circ}.5$ Mean Maximum $63^{\circ}.5$.

and in 1886 the extremes were

Mean Minimum $35^{\circ}.2$ and Mean Maximum $57^{\circ}.4$.

These observations show that the night temperatures remained low, but that there was a considerable increase of heat during the day, the maximum readings being from 11° to 17° higher than those for February. March was a very unsettled month throughout Afghanistan, and was very wet and cold. There was an average of 15 rainy or snowy days during the month, and the oscillations of temperature were frequently large. Thus when the wind was from the south-eastward, maximum temperatures as high as 86° and 87° were recorded, while with a northerly wind which brought up a cold drizzle, the maxima were very low. In both years the close of the month was marked by an abnormally cold period. In 1885 snow began on the 26th and continued till the close of the month, and in 1886 snow fell on the 29th and was succeeded by a period of hard frost, and the maximum temperatures were as low as 28° and 31° on the 30th and 31st. Comparing these readings with those given above, it shows that in this month there is a liability to a range of nearly 60° in the maximum readings.

April.—April 1885 was passed at Tirpul on the Hari Rud, about 80 miles west of Herat, and April 1886 at various camps near Maruchak in the north, and hence the two months are not strictly speaking comparable. For April 1885, there are only means of the 10 and 16 hours observations, so that the important point of the daily range of temperature cannot be ascertained. April in the Hari Rud appeared to possess many of the characteristics of the same month in higher latitudes. The weather was unsettled and showery, heavy rain for short periods alternating with fine warm days. The wind was high and squally, and temperature varied considerably before and after the showers. Thunderstorms with hail were not infrequent. In Afghan-Turkistan the mean minimum temperature of the month was 44.0° , and the mean maximum 68.6° ; the highest maximum

was 82° , the lowest 45° . Sharp frost prevailed at the commencement of the month, but towards the close the night temperatures were as high as 50° . The weather was similar to that in the Herat Valley, heavy showers with thunder and hail alternating with fine periods during which the sun shone with great heat.

May.—May 1885 was passed at Tirpul and at various camps near or in the hills to the north of Herat, and May 1886 at various camps in Afghan-Turkistan between Chahar-Shamba and Kham-i-Ab on the Oxus. The mean minimum for the month was 52.7° and the mean maximum 84.5° . In May the showers which are characteristic of April ceased, and the weather, except for an occasional thunderstorm, was fine and dry. There was, however, a good deal of difference in the weather in the tract of country lying to the north of Herat, and that in the Oxus plain during this month. In the former region strong northerly winds were experienced all day, and the weather was frequently so hazy as to obscure the sun. Near the Oxus, on the contrary, there was comparatively little breeze, and the sun was very powerful. Thundershowers occurred occasionally.

June.—June 1885, like May, was passed at various camps between the Hari Rud and Murghab Valley to the north of Herat, and June 1886 on the Oxus at Kham-i-Ab. In the latter position the range of temperature was—

Mean Minimum.

 63.8°

Mean Maximum.

 99.0°

In the highlands to the north of Herat, the weather as in May was very windy and thick, and though at times when the haze cleared the sun was hot, the wind was always cool and at times very cold. At Kham-i-Ab on the Oxus the breeze was at first from north-west or north-east, and the climate cool, but after the first week hot west winds set in. They generally commenced about 10 A.M., and lasted till 4 or 5 P.M., and were generally similar to the hot winds of Upper India. During the prevalence of these winds the thermometers in open tents rose to 109° or 110° , but this was only while the wind blew. The nights and mornings were cool, the sky clear and the air fresh. The climate was a hot summer, quite unlike an Indian hot weather.

July.—July 1885 was passed on the Hari Rud in the neighbourhood of Herat, and July 1886 mostly at Kham-i-Ab. The extremes of temperature in the latter position were—

Mean Minimum.

 62.4°

Mean Maximum.

 98.2°

In the former region very violent northerly winds and thick weather prevailed, while in the latter conditions were similar to those prevailing throughout June, *viz.*, hot and rather strong day-winds with quiet and cool nights. The highest temperature recorded at Kham-i-Ab was 110.7° on the 6th. There was no rain throughout the month in either region, so that it may be fairly safely concluded that this is generally a rainless period.

August.—Part of August 1885 was passed at Zindijan, a station about 25 miles west of Herat in the Hari Rud, and part at Sangbast, also in the Hari Rud and with similar characteristics. During this month the most pronounced feature in the weather was the tremendous wind which blew all day. The air was thick with haze, and the weather was hot, but nothing approaching an Indian hot weather. The extremes of temperatures were—

Mean Minimum.

 65.4°

Mean Maximum.

 91.5°

August 1886 was passed mainly at Shadian, about 15 miles to the south-south-east of Mazar-i-Sharif, about 5,700 feet above mean sea-level. Here the breeze was generally light and variable, and there was no sign of the strong hot winds which prevailed in the Herat Valley. Thick hazy weather was less prevalent here, but in the plains below, the mist was as thick as in the neighbourhood of the Hari Rud, and occasionally this haze extended upwards to Shadian. The general climate was exceedingly good and there was no rain. The extremes of temperature were—

Mean Minimum.	Mean Maximum.
54°1'	80°8'

September.—The month is generally rainless. In September 1885 the observations were recorded in the Hari Rud Valley, and the extremes of temperature were :—

Mean Minimum.	Mean Maximum.
51°4'	83°5'

With the commencement of September a change was inaugurated in the weather. After the 3rd the violent hot winds decreased, and by the 10th they had practically ceased. About this time clouds appeared in the north, and about the middle of the month rain may be expected. A brisk fall of temperature occurred during the month, and though the sun was powerful during the day, there was a decided sharpness in the air at night, and frost began at the close of the month. During September 1886, the observations were recorded at Kham-i-Ab, and at various camps between that station and Haibak on the road south-eastward to the Indian frontier. The extremes of temperature were :—

Mean Minimum.	Mean Maximum.
51°4'	85°4'

The weather was very fine and there was no rain during the month. The variations of temperature were considerable, some of the days being very hot and oppressive, and others very cool. A very decided fall of temperature, however, took place during the month.

October.—The records of three Octobers are available. During that of 1884, the observations were recorded along the valley of the Helmand, and the extremes of temperature were :—

Mean Minimum.	Mean Maximum.
48°7'	82°6'

Westerly winds prevailed almost continuously and the weather was hazy. Temperature was high during the day, but fell quickly after sunset.

The observations for October 1885 were recorded during a journey from Kuhsan to Meshad and back to Herat. The extremes of temperature were :—

Mean Minimum.	Mean Maximum.
36°3'	68°7'

The weather was fine with a moderate amount of cloud, but about the middle of the month some heavy rain fell.

October 1886 was passed in the journey from Haibak to the Indian frontier, and the extremes of temperature were :—

Mean Minimum.	Mean Maximum.
39°2'	75°4'

The weather was cool and generally fine though occasional showers fell.

November.—November 1884 was occupied in passing from Lash to Kuhsan on the Hari Rud, and the extremes of temperature were :—

Mean Minimum.

32° 3'

Mean Maximum.

65° 8'

The weather was changeable, some days warm and fine and others cold and unpleasant with a bitter north wind.

November 1885 was passed in the Herat Valley and the extremes of temperature, were :—

Mean Minimum.

36° 7'

Mean Maximum.

64° 9'

the weather was cloudy with a cold northerly (north-west to north-east) wind, and occasional rain.

December. :—December 1884 was passed mostly at Bala Murghab and the extremes of temperature were :—

Mean Minimum.

30° 2'

Mean Maximum.

53° 5'

The weather was very dull and damp, cold mists were frequently experienced, and the rainfall of the month was very slight, drops of rain falling on several days. December 1885 was also passed in the Murghab Valley close to the northern frontier of Afghanistan. The extremes of temperature were :—

Mean Minimum.

24° 7'

Mean Maximum.

52° 2'

Cloudy dull skies prevailed, with raw, chilly, disagreeable weather. Thick misty weather prevailed at times, the mist turned to ice and then snow fell, but at this season the snow does not, as a rule, lie in the valleys more than a day or two.

Colonel Maitland briefly describes the climate of Herat thus—"The climate of the Herat Province has four seasons as in Europe. Spring is supposed to commence about the middle of March, and each season to last three months. Winter is cold, with more or less snow, which does not, as a rule, lie very long. Spring is a rainy season, or rather the months of March and April are rainy, the end of February and beginning of March being often fine, with what may be described as enjoyable spring weather. The rainfall appears to depend on the amount of previous snow, and is greatest after severe winters. By May the weather is clear, and then the northerly wind sets in, which is famous as the "bád-i-sad-o-bist róz," or wind of 120 days. During these months the wind is very strong, being always highest after sunset, and if there should be rain on the hills to the northward, or a shower in Badghis, it increases almost to a hurricane. The wind is felt far to the south, and blows with unabated fury in Sistan. In Badghis, curiously enough, there is no wind. Moreover, the wind is not felt in the Herat Valley east of Tunian. When the wind is not blowing, the summer heat in the Herat Valley is great, though not to be compared with that of India."

Corrigenda in Vol. iv, Part viii. of the Indian Meteorological Memoirs.

Page	Subject.
529, 531, 533, 535, 537, 539, 541, 543, 545, 547, 549, 551, 553, 555, 661, 737, 751, 753, 755, 757, 759, 761, 763, 765.	For 'during the years from 1876-1891' read 'during the years 1876-1891' in the page heading.
550	Read 'Nil' against Bushire in the column of 'Rainfall of period, June to October' in the 1st table.
551	For 'Teharan' read 'Teheran' in the column of 'Representative Station' in the 1st table.
562	For '21th' read '12th' in line 2.
563	For 'firts' read 'first' in line 6.
"	For 'Storm of the 31st January 1877' read 'Storm of the 28th to the 31st January 1877' in line 7.
"	For 'indicate' read 'indicates' in line 1 after the table.
566	For 'flowinoig' read 'following' in line 1 after the table.
571	For 'N. Lyddeker' read 'R. Lyddeker' in line 4 after the table.
575	For '033" read "017" in line 2 after the 2nd table.
582	For 'In Bengal occasional rain' read 'In Bengal occasional rain was received' in line 11 after the 1st table.
583	For '17th to the 26th' read '17th to the 20th' in line 9 after the 1st table.
585	For 'advance' read 'advanced' in line 2 after the 1st table.
587	For 'Sirsa at 0 A.M., read 'Sirsa at 10 A.M.' in line 7 after the 1st table.
589	For 'Mutree' read 'Murree' in the column of station in the 2nd table.
599	For 'North-Western' read 'north-western' in line 2.
608	For 'o the transfer' read 'to the transfer' in line 4 after the 2nd table.
622	For 'diturbance' read 'disturbance' in line 9.
632	For 'scarccely any Northern' read 'scarcely any rain in Northern' in line 1.
"	For 'storm' read 'storms' in line 4.
66e	For '+17' read '? ' against Berar in the 3rd column of the table.
664	For '15th to the 22nd January' read '17th to the 20th January' in line 7 after the table.
"	For '18th to 28th January' read '18th to 20th January' in line 9 after the table.
673	For 'March 1885' read 'March 1886' in line 3.
679	Insert following table after the para. marked 4th.

MONTH.	VERTICAL PRESSURE ANOMALY.					
	Leh minus Lahore.	Quetta minus Jacobabad.	Murree minus Peshawar.	Simla minus Ludhiana.	Ranikhet minus Lucknow.	Darjeeling minus Dhubri.
September, 1886 . . .	+ '010	+ '002	+ '009	+ '011	— '024	+ '008
October " . . .	+ '020	+ '013	+ '018	+ '014	+ '005	+ '032
November " . . .	+ '018	+ '010	+ '024	+ '024	+ '004	— '010
December " . . .	— '027	— '006	— '011	+ '021	+ '001	— '006
January 1887 . . .	— '068	— '028	— '039	— '024	— '010	— '001
February " . . .	+ '022	+ '011	+ '004	+ '001	— '014	+ '017
Mean of period . . .	— '004	0	+ '001	+ '008	— '006	+ '007

67 X-C-23

Page	Subject.
681	Insert 'I.' at the beginning of para. 5.
686	For 'Nil' read 'Nil' against Agra, in the last column of the 2nd table.
690	Insert 'II.' at the beginning of para. 1.
697	For 'India' read 'Central India' in line 5 in the column of 'Area' in the table.
701	Insert 'I.' at the beginning of para. 3.
704	Insert 'II.' at the beginning of para. 4, after the 1st table.
713	Insert 'I.' at the beginning of para. 2.
714	Insert 'II.' at the beginning of para. 6 after the table.
"	For 'clear sikes' read 'clear skies' in line 19 after the table.
716	Insert 'III.' at the beginning of para. 2.
717	Insert 'IV.' at the beginning of para. 2.
734	Insert 'V.' at the beginning of para. 1.
738	Insert 'VI.' at the beginning of para. 2 after the 2nd table.
740	Omit '0/0' from the top of column 4 of the 1st table.
741	Omit '0/0' from the top of the columns 2, 3 and 4 of the 1st table.
"	Omit '0/0' from the top of the last column of the 2nd table.
743	Omit '0/0' from the top of the 4th column of the 2nd table.
750	Insert 'VII.' at the beginning of the last para.
752	Omit '0/0' from the top of the last column of the 2nd table.
754	Omit '0/0' from the top of the 3rd column of the 1st table.
755	Omit '0/0' from the top of the 3rd column of the 2nd table.
760	For 'it exceeded' read 'It exceeded' in line 4.
761	For '10,009 feet' read '10,000 feet' in line 31.
768	Insert '2.' at the beginning of the 2nd para.
772	Insert 'III.' at the beginning of line 15 after the table.
772	Insert 'III.' at the beginning of para. 4 after the 1st table.
778	For 'average rainfall' read 'normal average rainfall' in line 21.
780	Insert 'I.' at the beginning of line 10.
783	For 'eastern district' read 'eastern districts' in line 1.
786	Omit 'as is indicated by the snowfall reports in the next section' from sixth line of table.
"	For 'normally high' read 'abnormally high.'

POSTSCRIPT TO THE CORRIGENDA.

"Storms numbered 22 and 24 in the list of Chapter III were of such feeble intensity that they are excluded from the number of storms in the year 1881-82 in the various tables in the discussion of Chapter IV."



XII.—An account of the more important cold weather storms in India during the years from 1876-1891.

The present paper is devoted to the examination of an important class of depressions and storms in India which occur during the prevalence of the north-east monsoon and chiefly during the cold weather months of December, January and February. Economically they are of great importance, as the snowfall of the Himalayas (more especially of the western half) occurs chiefly during their existence. They also give more or less general rain to Northern India. Their economic importance is due to the fact that the character and value of the chief cold-weather crops of wheat, etc., in Northern India largely depend upon the amount and distribution of the rainfall during these storms of the cold-weather months. In some years, for example, the number of these storms is much less than usual and the rainfall scanty, and consequently the wheat crops fail more or less in all unirrigated districts, and the more elevated the district the greater the failure. In other years these storms are of frequent occurrence and give moderate to heavy showers at short intervals, and in such years the wheat crop of Northern India is generally a bumper one and there is usually a very large surplus available for export to Europe.

The storms present many features of much interest meteorologically. They originate during a period when dry land winds prevail in India, and when the lower atmospheric strata over Northern India contain only from a half to a third of the amount of moisture which is present in the air during the rains or south-west monsoon; hence there is a considerable difference of opinion as to their origin and the source of the aqueous vapour, the condensation of which gives rise to the rainfall accompanying these storms. Again, the great majority of these storms march in an easterly direction across Northern India, or in the opposite direction to that in which the south-west monsoon cyclonic storms and cyclones usually advance across Northern India.

They sometimes enter India from Beluchistan and advance across the whole breadth of India into Burma, where they disappear either by filling up or by marching into Further India, an area for which there are no meteorological observations at present available. So far as experience shows, they never enter India from the adjacent sea areas (except so far as depressions passing across South Beluchistan extend southwards into the North Arabian Sea). In these two features they differ entirely from the equally numerous cyclonic storms of the rains which generally advance westwards from the Bay of Bengal into India. Hence from a scientific as well as an economic point of view they deserve careful study.

Before describing the storms, it appears to be desirable to state some of the more important features of the meteorology of India during the cold weather months (December to March). This information will be utilized in the last portion of the present memoir in which the origin and more characteristic features of the storms will be discussed.

It may be premised that the year in India may be divided for meteorological purposes into—

1st—The cold weather season, from December 15th to March 15th.

2nd—The hot weather season, from March 15th to June 1st.

3rd—The period of the south monsoon rains proper, from 1st June to 15th October.

4th—The period of the retreating south-west monsoon, from 15th October to 15th December.

Temperature.—In the following paragraphs certain features of the distribution of temperature in India during the cold weather season are briefly discussed :—

Ferrel in his Meteorological Researches has calculated normal temperatures in different latitudes of the Northern Hemisphere. The following gives a comparison of these normal values for the months of January and July with the actual values in India :—

Latitude.	JANUARY.			JULY.		
	Actual in India.*	Normal.	Variation.	Actual.*	Normal.	Variation.
0°	81°0	81°1	—0°1	78°0	79°0	—1°0
10° N	80°0	78°6	+1°4	80°0	83°1	—3°1
20° N	73°5	71°1	+2°4	82°0	84°2	—2°2
30° N	60°0	55°2	+4°8	92°0	79°9	+12°1
35° N	50°0	47°6	+2°4	95°0	76°4	+18°6

These figures show :—

1st—That there is a very large excess of temperature in North-Western India during the south-west monsoon period.

2nd—That there is a slight excess of temperature in Northern India in January which is greatest in latitude 30° N., or in Rajputana and Central India.

This excess of temperature in Northern India, during the cold weather period, is undoubtedly due to the fact that the Himalayan mountain barrier shields it almost entirely from the cold, continental winds of Central Asia.

The winter circulation in India and the adjacent seas is an integral portion of the general circulation due to the permanent temperature differences between the equatorial and polar regions. It is, however, largely modified by the presence of the Himalayan mountains and by the higher temperature in India itself than prevails generally elsewhere in the Northern Hemisphere in the same latitudes. In consequence of these peculiarities the north-east monsoon winds in the Bay of Bengal and Arabian Sea should be weaker than in the Atlantic and Pacific Oceans.

Temperature in the cold weather months of December, January and February is moderately high in the Peninsula and Southern India, and is slightly higher in the south of the Bay of Bengal and Arabian Sea than in the Peninsula. It decreases rapidly northwards from the Vindhya mountains to the north of the Punjab. The following gives mean temperature data for the three months of December, January and February :—

DISTRICT.		MEAN DAILY TEMPERATURE IN			Mean of period.
		December.	January.	February.	
TROPICAL INDIA.	Madras	73°6	74°1	77°2	75°0
	Lower Burma	74°1	72°6	75°5	74°1
	Bombay	73°2	73°1	75°7	74°0
	Deccan	67°0	68°3	72°3	69°2
	Central Provinces (South)	65°1	66°5	71°0	67°5

* The means in these columns are taken from Mr. Buchan's charts. They are slightly higher than are shown by charts in the India Meteorological Office by Mr. Blanford. The slight differences do not, however, modify the general conclusions based on the figures.

DISTRICT.		MEAN DAILY TEMPERATURE IN			Mean of period.
		December.	January.	February.	
EXTRA TROPICAL INDIA	Bengal	65·9	65·0	68·8	66·6
	Behar	62·8	62·0	65·9	63·6
	North-Western Provinces	60·1	59·3	63·6	61·0
	Central India . .	61·3	61·8	65·1	62·7
	Rajputana	63·0	61·6	64·9	63·2
	Sind	64·3	62·8	66·3	64·5
	Punjab	54·6	53·1	56·8	54·8

The figures of the preceding table also show that the mean monthly temperature varies little in Northern India during these months, and that January is the coolest month. In the Peninsula or Tropical India, December is usually the coolest month, and temperature increases rather rapidly in February. The highest monthly temperatures in India in December and January are registered in Malabar, South Madras and the Andamans, and in February in the South Deccan and Malabar.

The following gives data for stations in those areas :—

DISTRICT.	STATION.	Elevation in feet.	MEAN DAILY TEMPERATURE IN			Mean of period.
			December.	January.	February.	
Malabar	Cochin	11	78·9	78·7	80·1	79·2
South Madras . .	Madura	445	76·8	77·0	79·1	77·6
Andamans	Port Blair	61	79·2	79·2	79·6	79·3
Central Deccan . .	Cuddapah	433	74·9	76·2	80·7	77·3
	Kurnool	923	73·4	75·3	79·9	76·2

The mean daily temperature of the south of the Bay of Bengal and Arabian Sea is very approximately 80° throughout the year.

The coolest area throughout the whole period in question is the North Punjab. The following gives data for the three coolest stations :—

STATION.	Elevation in feet.	MEAN DAILY TEMPERATURE IN			Mean of period.
		December.	January.	February.	
Peshawar	1,110	50·9	49·9	51·8	50·9
Rawalpindi	1,652	50·3	48·6	51·6	50·2
Dera Ismail Khan	572	54·0	52·4	56·4	54·3

These means are not corrected for height above the sea level. Allowing 1° for every 450 feet the mean temperature of the period of the North Punjab is 53½° or 26½° below that of Southern India and the equatorial belt.

It may be noted that there is a considerable diminution of temperature in passing north wards from the Central Provinces across the Satpuras and Vindhya into Central India.

The following gives data :—

STATION.		Elevation in feet.	Latitude north.	MEAN DAILY TEMPERATURE IN			Mean of period.
				December.	January.	February.	
SOUTHERN STATIONS	Amraoti . . .	1,215	20° 55'	67·8	69·4	73·8	70·3
	Akola . . .	930	20° 42'	66·1	68·3	72·8	69·1
	Nagpur . . .	1,025	21° 9'	66·9	68·6	73·4	69·6
	Raipur . . .	960	21° 15'	65·7	67·0	71·3	68·0
INTERMEDIATE STATIONS	Khandwa . . .	1,044	21° 40'	64·9	66·9	70·3	67·4
	Hoshangabad . . .	1,030	22° 45'	65·6	65·8	69·7	66·7
	Jubbulpore . . .	1,327	23° 9'	60·8	62·0	65·9	62·9
NORTHERN STATIONS	Indore . . .	1,823	22° 44'	62·3	63·9	66·4	64·2
	Saugor . . .	1,761	23° 49'	63·7	63·3	67·1	64·7
	Sutna . . .	1,040	24° 34'	60·2	60·7	64·4	61·8

The following table gives a summary of the preceding data :—

	Mean elevation.	Mean Latitude N.	Mean temperature, December to February.
Southern Stations	1,032	21°	69·3
Intermediate Stations	1,134	22½°	65·7
Northern Stations	1,540	23½°	63·5

A reference to the data of the last table but one will show that elevation apparently exercises very little influence in determining or modifying the temperature in this area. The summary establishes that there is a difference of 5·8° for 2½° difference of latitude in this part of India. Even if allowance be made for difference of elevation, the decrease would be very nearly 5° in this distance.

The following gives corresponding data for the Punjab in which area temperature also decreases rapidly with increasing latitude :—

	Mean elevation.	Mean latitude.	Mean temperature.
Northern stations (Peshawar and Sialkot)	970	33½°	52·4
Intermediate stations (Lahore and Ludhiana)	757	31½°	54·9
Southern stations (Roorkee, Delhi and Sirsa)	755	29°	58·5

This gives a decrease of 6·1° in 4½° of latitude, a rate of decrease little more than half of that in the first case. It is hence evident that the comparatively low lines of hills across the Head of the Peninsula exercise a considerable influence in modifying the temperature conditions in Central India, the Central Provinces and North Deccan. This

is due to the fact pointed out in page 539 that the winds in Rajputana and Central India are not continued across these mountains and hence that the Central Provinces are to a considerable extent cut off from the cool winds originating in and coming from Upper India.

The cold weather period is one of large daily range of temperature over the whole of India excepting the coast districts. The following gives data of the average diurnal range of temperature in different districts :—

	DISTRICT.	MEAN DAILY RANGE OF TEMPERATURE IN			Mean of period.
		December.	January.	February.	
TROPICAL INDIA	Madras	18'4	22'2	26'2	22'3
	Bombay	26'6	28'1	31'5	28'7
	Deccan	29'0	29'1	31'5	29'9
	Central Provinces	28'0	27'6	29'4	28'3
	Lower Burma	19'7	24'9	28'7	24'4
EXTRA TROPICAL INDIA.	Bengal	21'7	22'6	23'8	22'7
	Behar	23'1	24'1	26'0	24'4
	North-Western Provinces	27'9	25'7	27'5	27'0
	Central India	28'9	28'1	29'8	28'9
	Rajputana	31'4	29'9	31'3	31'1
	Sind	30'0	28'1	27'9	28'7
	Punjab	30'2	25'6	26'0	27'3

The following gives data for representative stations in North-Western and Central India :—

DISTRICT.	STATION.	MEAN DAILY RANGE OF TEMPERATURE IN			Mean of period.
		December.	January.	February.	
PUNJAB	Rawalpindi	31'8	25'4	24'2	27'1
	Lahore	30'3	25'2	25'9	27'1
	Sirsa	32'9	28'4	29'8	30'4
	Roorkee	29'2	25'2	26'4	26'9
NORTH-WESTERN PROVINCES.	Agra	27'9	25'1	26'9	26'6
	Lucknow	30'2	27'9	28'7	28'9
	Allahabad	27'4	26'1	28'9	27'5
	Patna	23'1	23'0	25'9	24'0
BEHAR	Furneah	26'7	26'8	28'4	27'3
	Hazaribagh	21'3	22'3	23'9	22'5
SIND	Jacobabad	33'6	30'5	29'7	31'3
	Hyderabad	26'3	25'6	26'1	26'0

DISTRICT.	STATION.	MEAN DAILY RANGE OF TEMPERATURE IN			Mean of period.
		December.	January.	February.	
RAJPUTANA	Deesa	32·9	31·1	31·0	31·7
	Jeypore	29·5	25·1	28·1	27·6
CENTRAL INDIA	Sutna*	28·5	27·1	28·4	28·0
	Saugor	24·5	25·2	26·4	25·4
	Indore	29·4	28·2	31·0	29·5
CENTRAL PROVINCES AND BERAR.	Nagpur	27·1	27·3	29·9	28·1
	Jubbulpore	30·7	28·6	30·2	29·8
	Akola	31·9	30·9	33·7	32·2

These figures show that the area of greatest mean daily range includes Sind, Rajputana, Central India, the Deccan, the Central Provinces and Berar. This is chiefly due to the fact that skies during this period are more free from cloud in these districts than in Northern India, and not to their being drier or more exposed to land or continental winds.

An interesting feature is the small daily range of temperature at the hill stations as compared with the plain stations. The following table gives data in illustration:—

STATION. H—HILL, P—PLAIN.	AVERAGE DAILY RANGE OF TEMPERATURE IN			Mean of period.
	December.	January.	February.	
H. Murree	14·1	12·3	13·4	13·3
P. Rawalpindi	31·8	25·4	24·2	27·1
H. Simla	16·4	14·8	16·3	15·8
P. Ludhiana	28·4	24·1	25·8	26·1
H. Chakrata	15·4	14·4	15·3	15·0
P. Roorkee	29·2	25·2	26·4	26·9
H. Ranikhet	15·7	14·5	15·2	15·1
P. Bareilly	27·3	24·2	26·5	26·0
H. Darjeeling	12·1	9·7	12·0	11·3
P. Dhubri	18·7	19·9	22·8	20·5
H. Mount Abu	16·6	16·2	16·1	16·3
P. Deesa	32·9	31·1	31·0	31·7

The average daily range of temperature at the hill stations in Northern India very approximately half of that at the neighbouring plain stations.

The preceding discussion has hence shown that in Northern and Central India, the mean monthly temperature is almost uniform during the three months of December, January and February; the chief temperature changes of this period are hence chiefly due to the cyclonic storms which occur at more or less frequent intervals during the cold weather. It is always a period of large daily range of temperature, the mean range being slightly greater in Sind, Rajputana, Central India and the Deccan than

in the Punjab and the Gangetic plain. This is due to more frequent and somewhat larger cloud amount in the latter than in the former areas: on the other hand, the largest range of temperature in 24 hours is almost invariably observed in the Punjab or North-Western Provinces during the cool periods following the more severe storms of the cold weather. The following gives the place and date of the largest range of temperature in 24 hours during the months of December, January and February of the five years 1886-1890:—

PLACE WHERE RECORDED.	Highest range of temperature in 24 hours observed in December to February.	Year.
Sirsa	56°0	February 1886.
Do.	66°2	Do. 1887.
Mooltan	48°9	Do. 1888.
Lahore	46°8	January 1889.
Allahabad	54°4	February 1890.

Cold weather or winter distribution of pressure in Asia and atmospheric circulation.

European meteorologists, more especially Hann and Buchan, have devoted much time to the investigation of the distribution of pressure over the earth's surface at different periods of the year. Charts giving the distribution of pressure in January and July are to be found in many physical atlases and works of general meteorology. The most recent investigations of importance are those of Hann and Buchan. The latter meteorologist has devoted many years to the collection and discussion of such data and has recently published a most valuable paper in the *Journal* of the Royal Geographical Society embodying his latest results. His paper includes a series of charts of the distribution of pressure month by month of which those of the months of January and July have been published in the *Journals* of the Geographical Society. Mr. Buchan's pressure chart for January shows very considerable differences from those of Dr. Hann and others. The causes of these differences are probably the following. A large portion of Central Asia is an elevated plateau, very sparsely populated, and the only observations available as yet for it are the occasional observations which have been taken by travelers. These are so few in number comparatively as to be probably insufficient for the determination of satisfactory means. In the second place the barometric observations taken on the Central Asia plateau were in many cases probably taken at great elevations and reduced to sea-level by means of one or other of the formulæ devised for the purpose. In these formulæ a law of variation of temperature with elevation is assumed which, even if it were true on the average of the whole year, undoubtedly differs very widely from the truth at certain seasons of the year, and especially at the coldest and hottest periods of the year. Hence the distribution of pressure, as laid down in these charts, although probably correct as to the general character of that distribution, is more or less hypothetical so far as the actual distribution and gradients are concerned.

So far as I am able to judge, the pressure distribution in Asia of the month of January, as laid down in Mr. Buchan's charts, is most in accordance with the facts of the

meteorology of India during the cold weather, and I hence use it chiefly in drawing up the following statements of the winter pressure distribution in Asia.

The Continent of Asia, and more especially Central Asia, is an area of very high pressure during the northern winter. The central area of maximum pressure covers the greater part of Central Asia stretching from Ladakh across Thibet to the southern base of the Altai mountains. The average pressure in January in this area slightly exceeds 30.5 inches. This excessive pressure is apparently a feature of the high plateaux of Central Asia and not of the Siberian low ground of lowest temperature. Pressure diminishes in all directions from this central area, but the steepness of the descending pressure gradients appears to differ very largely in different directions. The steepest gradients are in Manchooria and East Siberia to the north-east and over the mountain area including the Himalayas to the south. In the Himalayan mountain area pressure decreases in a southerly direction four-tenths of an inch in a distance of less than 500 miles, this corresponds to gradients of about 6 in the English scale.

Gradients are, on the other hand, much smaller to the north and more especially to the west of the central area, and pressure diminishes in that direction at an average rate of about a tenth of an inch in 500 miles.

In the peninsulas of Southern Asia and adjacent seas which lie to the south of the great plateau of Central Asia and its high mountain rampart, pressure decreases slowly southwards to the neighbourhood of the Equator. The average difference of pressure in January between Northern India and the equatorial belt very slightly exceeds two-tenths of an inch over a distance of about 30° of latitude. The isobars run approximately east and west and the gradients are usually somewhat steeper in Northern than in Southern India and the Bay of Bengal. A belt or zone of low pressure runs across the Indian Ocean near the Equator. This equatorial belt of low pressure separates the north-east monsoon or Indian area to the north from the region of the south-east trades in the Indian Ocean. In the eastern portion of this area or belt, and extending from about 85° to 100° east longitude, pressure appears to be considerably lower than in the western portion. This is almost certainly due to the heating of the Australian Continent during the southern summer.

One important effect of this distribution of pressure in the equatorial belt is to give westerly winds in the neighbourhood of the Equator to the west and south of Java and Sumatra. If it were not for this disturbing effect of great thermal action in North and Central Australia, the winds in this area would undoubtedly be east or light and variable. These westerly winds constitute what is known to sailors as the westerly monsoon of the line.

The preceding sketch has stated the prominent features of the cold weather distribution of pressure in Central and Southern India.

If the ideal construction of the distribution of pressure described in the preceding paragraphs represented the real barometric gradients which controlled the lower air circulation or winds in Central and Southern Asia, it is evident that steep southerly horizontal gradients would obtain over the Himalayan mountain area and moderate southerly gradients over India and the adjacent seas and slight westerly gradients in Afghanistan, Persia and Turkistan. The lower air circulation or winds corresponding to these gradients would evidently be easterly in Northern India, northerly to north-easterly in Burma, north-easterly in the Bay of Bengal and peninsula, easterly in the Arabian Sea and

south-easterly in Afghanistan and Turkistan. The actual mean winds at the earth's surface in Northern India and Burma differ very considerably from these. The actual winds are weakest where they should be strongest and blow from the opposite directions over a considerable portion of this area.

In Burma northerly winds generally obtain and in Assam easterly winds, in both cases being evidently determined by the direction of the river valleys. In the Indo-Gangetic or great plains of Northern India north-westerly to westerly winds prevail which increase in force from west to east. In Chutia Nagpur they vary in direction between north-west and north-east. The south-easterly drift across Rajputana and the western districts of the North-Western Provinces is continued as a southerly, south-westerly and westerly movement across Central India, and the southerly and south-westerly drift across the Bay of Bengal is continued as a westerly drift across the peninsula and feeds into the general air movement over the Arabian Sea. The lower air movement over the Indian land and sea area is thus a part of a well-defined circulation, and it causes a slow but fairly steady transfer of air from Northern India and Upper Burma to the equatorial belt or zone of low pressure.

There are a number of interesting points in connection with this circulation which are deserving of note, more especially as they will be referred to in a later chapter discussing the general characteristics of the cold weather storms of Northern India.

In the first place the wind data of Northern India appear to establish that the current in Northern India does not extend as a general horizontal current further westwards than Upper India, and is not the continuation of a strong current across the mountains or down the mountain valleys. There is undoubtedly some drift down the mountain sides and through the passes. This drift, so far as I have been able to ascertain its sufficiency, is not large enough to give rise to winds except in special cases. Thus, when a broad and open valley in the hills communicates with the plains through a narrow opening or pass, as at Hurdwar and Kathgodam, strong winds undoubtedly blow at night down these passes into the plains. Even in those cases the wind is confined to the immediate neighbourhood of the hills and merges into the general circulation of the plains at a distance of a few miles (usually less than 10 miles) from the foot of the hills.

The general character of the cold weather air movement in Northern India appears to be clearly indicated by the following facts and data:—

1st—The winds in Northern India during the cold weather are feeblest in the Punjab and increase in strength eastwards. This is established by the following data:—

PROVINCE.	MEAN AIR MOTION MILES PER HOUR.				Mean of the period.
	November.	December.	January.	February.	
Punjab	35	37	43	57	43
Upper Sind	37	37	50	71	49
North-Western Provinces	35	40	55	72	51
Behar	41	45	54	79	55
Bengal, Inland	50	49	51	65	54
Bengal Coast	156	152	149	186	161

2nd—Winds in Northern India are most variable and unsteady in the Punjab and

increase in steadiness eastwards to Bengal. This is established by the following data giving mean percentage of steadiness.

PROVINCE.	AIR PERCENTAGE OF STEADINESS.				Mean of the period.
	November.	December.	January.	February.	
Punjab	21	17	19	24	20
Sind	16	22	27	36	25
North-Western Provinces	35	35	33	40	36
Behar	42	55	46	47	47
Bengal, Inland	55	58	42	36	47
Bengal Coast.	58	60	21	20	40

3rd—The air movement during the cold weather is chiefly a slow drift down the Gangetic plain during the day. In fine settled weather there is hardly any movement at night. If the movement was the continuation of a drift from the higher ground of Afghanistan and Beluchistan through the Khyber and other passes of the north-west frontier, or across the Suleiman mountains, general considerations appear to show that the movement would be strongest at night and not by day.

The following data show the contrast between the air movement by day and night at two stations in the Gangetic plain for January 1889, a month fairly typical of ordinary cold weather conditions:—

STATION.	Mean amount of wind, 6 A.M. to 6 P.M., January 1889.	Mean amount of wind, 6 P.M. to 6 A.M., January 1889.
Roorkee	49	28
Lucknow	92	48

4th—The mean wind directions at the frontier stations of Peshawar, Dera Ismail Khan and Jacobabad furnish no evidence of the existence of a steady drift from Afghanistan and Beluchistan into India, and appear to indicate that the air movement in this part of India during the cold weather is a feeble and unsteady drift down the Indus Valley, and hence a local circulation determined by topographical conditions. The following table gives mean wind data from November to February for these stations taken from the Report on the Meteorology of India for the year 1889:—

STATION.		Month.	Normal Wind Direction.	Normal Steadiness.	Normal daily Velocity.
PUNJAB	PESHAWAR	November	N 85° E	18	52
		December	S 20° E	9	59
		January	S 11° E	7	59
		February	N 51° W	9	78

	STATION.	Monthly	Normal Wind Direction.	Normal Steadiness.	Normal daily Velocity.
PUNJAB . . .	DERA ISMAIL KHAN	November	N 51° E	21	18
		December	N 3° E	16	19
		January	N 7° W	30	34
		February	N 4° W	27	57
SIND	JACOBABAD . . .	November	N 12° W	16	37
		December	N 15° W	22	37
		January	N 10° W	27	50
		February	N 17° E	36	71

Hence the important inference from the preceding data that the lower air movement in Northern India is not a part of an anticyclonic motion due to the high pressure conditions in Central Asia, and that the Himalayas form an effective barrier so far as this is concerned. This is further proved by the fact that at the hill stations in Upper India the winds blow from the direction of the plains to the mountains, and give no evidence of a general drift from the mountains to the plains of Northern India at this time. The following gives mean wind directions for all the hill stations in Northern India :—

PROVINCE.	HILL STATION.	November.	December.	January.	February.
PUNJAB . . .	Murree	S 46° E	S 58° E	S 54° E	S 39° E
	Simla	S 89° W	N 83° W	S 31° W	S 22° W
NORTH-WESTERN PROVINCES.	Chakrata	S 55° W	S 55° W	S 66° W	S 54° W
	Ranikhet	S 52° W	S 54° W	S 70° W	S 55° W
BENGAL . . .	Darjeeling	N 61° W	N 54° W	S 84° W	S 83° W

It might be objected to the preceding data that they give the mean direction of the air motion during the day and not during the night as they are derived from 10 and 16 hours' observations only.

The following gives some data for the three stations, Darjeeling, Lahore and Allahabad for the year 1888 selected at random. The data indicate that there is no large difference between the direction of the mean air motion in Northern India during the day and that during the night :—

STATIONS.	Year.	November.	December.	January.	February.
Darjeeling (mean of 4 hours)	1888	S 56° W	S 36° E	?	?
„ (mean of 10 and 16 hours)	„	S 33° W	S 40° E	N 1° E	S 55° W
Lahore (mean of 4 hours)	„	E	N	N	N 52° W
„ (mean of 10 and 16 hours)	„	N 85° W	N 37° W	N 61° W	N 28° W
Allahabad (mean of 6 hours)	„	S 9° W	N 79° W	N 48° W	N 74° W
„ (mean of 10 and 16 hours)	„	N 31° W	N 62° W	N 53° W	N 57° W

It may be noted that at Lahore calms prevailed almost without exception at 4 A.M. in the cold weather months of 1887-88. Thus there were 28 calms in the 30 observations of wind at 4 A.M. in November, 28 out of 31 in December and also in January, and 22 out of 28 in February. It is, in fact, a striking example of the absence of air motion during the nights of the cold weather in Upper India.

It is also important to note that the air motion is even feebler and smaller in amount at the hill stations in Northern India than at the neighbouring plain stations, and hence that the normal air movement in the Himalayan mountain area is probably local and feeble in character, and not part of a general and extensive atmospheric circulation. This feature as shown by the following data is apparently not true for Murree and Chakrata, but as will be shown in the final discussion, the cold weather storms chiefly increase the air motion at the hill stations in Upper India, whilst they rarely influence the strength of the winds in the plains to any considerable extent. Hence, in order to compare properly the ordinary air motion at the hills and plain stations, it would be necessary to separate the ordinary winds from the winds due to these cyclonic storms. It would not be possible to do this without great labour. It will suffice to give an example. In January 1889, ordinary winds of fine anticyclonic weather obtained at Murree on 16 days, and on 15 days of the month the winds were largely influenced by the cold weather storms of the month. The mean air velocity of the 16 days of fine weather was 5·8 miles per hour, and of the remaining 15 days of more or less stormy weather 15·6 miles per hour. Remembering this contrast between the ordinary fine weather winds and the frequent stormy winds in the Punjab Himalayas, it will be seen from the following data that the air movement in ordinary weather and more especially in fine clear anticyclonic weather is much smaller at the hill stations in Northern India (except perhaps Murree) than at the level of the plains:— ! .

PROVINCE.	HILL STATION.	WIND FORCE.		Neighbouring Plain Station.	WIND FORCE.	
		Miles per hour.	Miles per diem.		Miles per hour.	Miles per diem.
PUNJAB . . .	Murree	8	194	Rawalpindi	2	46
NORTH-WESTERN PROVINCES.	Chakrata	5	116	{ Roorkee	2	52
	Ranikhet	1½	33	{ Meerut	2	51
	Darjeeling	2½	62	Bareilly	3	67
BENGAL . . .				Dhubri	4	93
CENTRAL PROVINCES	Pachmarhi	3	72	{ Hoshangabad	3	60
				{ Nagpur	3	73
BERAR	Chikalda	5	111	Buldana	6	133
RAJPUTANA . .	Mount Abu	5	116	Deesa	9	207

The preceding data appear to establish that the lower air motion in Northern India and the adjacent Himalayan mountain area is a local circulation (the north-east monsoon circulation of the Indian area) and not an integral part of the general Central Asian anticyclonic circulation. Hence, as might be expected under these conditions, the lower air

current in Northern India during the cold weather is a comparatively shallow one. This is at once seen by comparing the mean wind directions at the hill stations and neighbouring plain stations in every part of India :—

DISTRICT.	HILL STATION.	Mean wind direction.	Neighbouring plains station.	Mean steadiness and wind direction.
SOUTHERN INDIA	Wellington	62 S 14° E	Coimbatore	78 N 74° E
CENTRAL PROVINCES AND BEHARS	Chikalda	26 S 47° W	Buldana	21 N 76° E
	Pachmarhi	13 N 68° W	Hoshangabad	39 N 59° E
			Nagpur	30 N 72° E
CENTRAL INDIA	Mount Abu	6 N 83° W	Deesa	39 N 3° W
NORTHERN INDIA	Darjeeling	22 S 84° W	Dhubri	20 N 74° E
	Chakrata	9 S 66° W	Roorkee	16 N 72° W
	Ranikhet	17 S 70° W	Bareilly	2 N 55° W
	Simla	19 S 31° W	Ludhiana	25 N 56° W
	Murree	35 S 54° E	Rawalpindi	N 72° W

This table proves conclusively that the cold weather lower air current over a large part of India and probably over the whole of India is a comparatively shallow current, and also that above 4,000 or 5,000 feet the mean movement is from the west or south-west, and is not a part of the general drift from north-east over the Indian north-east monsoon area. The mean wind directions at the Himalayan hill stations show that there is not only no general drift from the north at that elevation, but that the mean movement is actually in the opposite direction. The movement of the cirrus clouds, as is established in the following paragraphs, show, that in the higher atmospheric strata over the whole of Northern India the drift is from west or west-south-west. The mean cirrus cloud movement, so far as it has been determined at Simla and other hill stations, gives no evidence of any other general drift. There are undoubtedly abnormal movements immediately before and during the storms of the cold weather, but this is what might naturally be expected, as the Himalayan region is usually in the northern quadrant of these storms which are of high elevation, and hence cause the usual cyclonic shift of wind and of cloud motion.

It may be noted in further confirmation that there is a large and irregular change of wind direction in passing from stations situated immediately to the north of the Vindhya to those to the south of the Satpuras. The following gives mean wind data for representative stations :—

STATION.		December.	January.	February.	Mean of period.	Mean velocity of period.
NORTHERN STATIONS .	{ Indore . . .	35 N 88° E	11 N 62° E	10 N 1° E	N 51° E	60
	{ Neemuch . . .	22 S 21° E	23 S 6° W	31 S 43° W	S 20° W	203
	{ Saugor . . .	38 N 37° E	24 N 13° E	24 N 6° W	N 15° E	65

STATION.		December.	January.	February.	Mean of period.	Mean velocity of period.
INTERMEDIATE STATIONS	Sutna . . .	39° N 31° W	27 N 16° W	38 N 41° W	N 30° W	99
	Pachmarhi . . .	22 N 29° E	13 N 68° W	24 N 49° W	N 23° W	76
	Chikalda . . .	9 N 88° W	26 S 47° W	29 N 75° W	S 81° W	125
	Malegaon . . .	39 N 83° E	8 N 65° E	21 N 9° E	N 52° E	99
SOUTHERN STATIONS	Akola . . .	58 N 61° E	30 N 54° E	25 N 1° E	N 39° E	83
	Amratoti . . .	48 N 85° E	16 N 70° E	5 N 6° E	N 54° E	80
	Nagpur . . .	52 N 64° E	30 N 72° E	17 N 55° E	N 64° E	78

The preceding data show that to the south of the Satpuras the mean wind direction is approximately east-north-east, and the air movement is part of the general easterly drift of the period across the Deccan. In the districts to the north and the intermediate stations the air movement is less regular. The mean direction at the intermediate hill station is north-west and on the Central Indian plateau it is north.

Upper air movement in the cold weather in India.

To the lower air movement described in the last paragraph there must be a corresponding upper air movement. Over and near the Equator, in the sea area forming the entrance to the Bay of Bengal and Arabian Sea, where there is almost continuous ascensional movement due to the influx of the north-east and south-east trade winds during the period November to May theory appears to require there should be a very strong westerly air movement in the upper strata. This is in part due to the influence of the earth's rotation which is equivalent to an acceleration in the westerly direction and in part to the westerly component of motion possessed by the air drawn into and rising over the equatorial belt or area of calms in that. It is almost certain that this westerly element of the Equator obtains up to a very great height. The existence of this strong westerly current in the higher atmospheric strata over the Equatorial belt has been fully established by the drift of the finer dust ejected by volcanic eruptions in Java, and the neighbouring islands, and more especially, the Krakatao eruption (*vide* Ferrel's Popular Treatise on the Winds). The following gives data of upper cloud movement registered by captains on board vessels in the south of the Bay of Bengal during the past two years:—

MONTH.	Position Latitude.	TOTAL DIRECTION UNDER															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
November	0° to 10° South	...	...	...	...	2	1	...	...	...	...	...	1	...	...	...	...
	0° to 10° North	...	...	...	...	...	...	...	...	...	...	...	3	1	...	...	...
	10° to 20° North	...	...	4	...	3	...	...	...	...	...	...	...	1	...	...	...
December	0° to 10° South	...	...	...	1	...	2	...	...	1	...	2	...	...	...	3	...
	0° to 10° North	...	...	...	...	...	1	...	2	1	...	...	...	...	...	1	2
	10° to 20° North	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
January	0° to 10° South	...	...	...	...	...	1	2	...	3	...	...	...	...	...	...	...
	0° to 10° North	...	...	...	...	...	1	1	...	...	...	...	...	...	...	...	...
	10° to 20° North	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...

MONTH.	Position Latitude.	TOTAL DIRECTION UNDER															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
February	0° to 10° South.	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...
	0° to 10° North	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
	10° to 20° North	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
Total November to February.	0° to 10° South	...	...	...	1	2	4	3	...	4	...	2	1	...	...	3	...
Total November to February.	0° to 10° North	...	...	...	...	...	2	1	2	1	...	...	3	1	...	1	2
Total November to February.	10° to 20° North	...	...	4	...	3	...	...	...	...	...	...	...	3	...	...	...

The resultant direction of the upper cloud movement or the direction of the upper air current in the Bay between Lat. 0° to 10° south is S. 31° E., and that between Lat. 0° to 10° North is S. 39° W., and that between Lat. 10° to 20° North is N. 45° E. These results have been obtained from a very few series of observations, and differ too largely to be accepted as valid. They hence unfortunately throw no light on the present discussion for which they were in part intended.

Theory also indicates that there should be a northerly movement or drift of the upper air in the Tropics, and that the upper air in this northerly movement will be deflected eastwards. Hence, the upper air movement in the cold weather, when the normal geographical conditions of temperature prevail, should be from some direction between south and west depending upon the latitude of the place of observation.

The movements of the upper or cirrus clouds have been carefully observed at Calcutta and Allahabad by means of nephoscopes during the past 13 years. The following gives a statement of the number of times the direction of their motion has been estimated, arranged according to sixteen points:—

MONTH.		DIRECTION.															
		N	NNE	NE	ENE	E	ESE	SE	SSE	S	SSW	SW	WSW	W	WNW	NW	NNW
November	Calcutta	4	2	5	...	6	...	1	1	6	...	45	2	42	...	11	1
	Allahabad	1	...	...	...	...	...	...	...	1	...	5	9	16	3	...	...
December	Calcutta	9	...	2	...	1	...	2	...	4	...	19	3	51	...	14	3
	Allahabad	...	...	...	...	...	...	...	...	...	1	20	21	16	4	2	...
January	Calcutta	...	...	...	...	1	...	1	...	3	3	18	1	63	...	14	...
	Allahabad	...	...	...	...	...	...	...	...	...	...	31	16	64	29	23	2
February	Calcutta	...	...	...	...	...	...	...	...	...	2	25	1	53	...	8	3
	Allahabad	1	...	...	...	1	...	...	...	3	...	15	13	76	...	8	2
Total	Calcutta	13	2	7	...	8	...	4	1	13	5	107	7	209	...	47	7
	Allahabad	2	...	...	...	...	...	...	...	4	1	71	59	172	26	35	4

Observations of the movement of the upper clouds have also been taken by eye (without the aid of nephoscopes) at Kailang (elevation 10,087 feet) in the Punjab Himalayas during the six years 1883-88 and at Lahore during the year 1891. The means for Kailang and Lahore are not strictly comparable with those for Calcutta and Allahabad, as the cloud movements in the former cases were recorded locally eight points of the compass

and in the latter to sixteen, also the periods of observation at Lahore and Kailang are much shorter than at Calcutta and Allahabad. The following gives a summary of these observations :—

Movements of the upper cloud observed at Kailang during six years (1883 to 1888).

MONTH.	DIRECTION.							
	N.	NE.	E.	SE.	S.	SW.	W.	NW.
November . . .	8	...	1	...	8	11	30	1
December . . .	4	...	1	...	14	13	36	1
January . . .	2	...	2	1	12	11	24	1
February . . .	6	...	4	...	6	13	24	...
TOTAL .	20	...	5	1	40	48	114	3

Movement of the upper or cirrus clouds observed at Lahore in the year 1891.

MONTH.	DIRECTION.							
	N.	NE.	E.	SE.	S.	SW.	W.	NW.
November . . .	...	...	...	...	...	1	7	...
December . . .	...	...	...	...	...	...	3	...
January . . .	...	...	...	...	1	...	13	1
February . . .	...	...	...	...	...	1	5	...
TOTAL .	...	...	...	...	1	2	28	1

The following table gives a general summary of the preceding upper cloud data showing the resultant direction for each month during the cold weather :—

STATION.	Number of years.	RESULTANT DIRECTION FOR THE MONTHS OF				Mean of Season.
		November.	December.	January.	February.	
Calcutta . . .	13	S 70° W	S 84° W	S 87° W	S 89° W	S 83° W
Allahabad . . .	13	N 87° W	S 75° W	S 82° W	S 84° W	S 85° W
Kailang . . .	6	S 78° W	S 67° W	S 59° W	S 74° W	S 70° W
Lahore . . .	1	S 85° W	W	S 89° W	S 83° W	S 87° W

With the exception of the slightly anomalous resultant for the month of November at Allahabad the results are very consistent. The following points are worthy of note :—

1st—That the direction of motion of the cirrus clouds and therefore of the upper air movement is almost due east in the cold weather. This in strict accordance with theory (*vide* Ferrel's Popular Treatise on the Winds, pages 121 to 126).

2nd—The winds in the higher strata are slightly more westerly at Allahabad than at Calcutta. This is also in accordance with theory, as the westing of southerly winds due to the earth's rotation increases with latitude.

3rd—The westing of these winds increases at both stations steadily from November to February. Theory indicates, the simplest explanation of this to be decreasing velocity of these winds.

For the sake of comparison the resultant directions for Calcutta and Allahabad are given for the four quarters of the year :—

	CALCUTTA (ALIPORE).					ALLAHABAD.				
	1st quarter, January to March.	2nd quarter, April to June.	3rd quarter, July to September.	4th quarter, October to December.	Mean of year.	1st quarter, January to March.	2nd quarter, April to June.	3rd quarter, July to September.	4th quarter, October to December.	Mean of year.
1878	N 86° W	S 42° W	S 7° E	S 36° E	S 23° W	W	S 85° W	S 5° W	S 49° W	S 58° W
79	S 72° W	S 28° W	S 21° E	S 8° W	S 21° W	W	S 80° W	S 23° E	S 63° W	S 57° W
80	S 51° W	S 23° W	S 55° E	N 73° W	S 38° W	S 68° W	N 84° W	N 35° W	N 79° W	S 79° W
81	S 79° W	S 53° W	S 19° W	S 67° W	S 60° W	S 89° W	S 89° W	S 48° W	W	S 79° W
82	N 81° W	S 46° W	S 29° E	S 83° W	S 56° W	S 79° W	S 84° W	S 27° E	S 65° W	S 56° W
83	N 85° W	S 43° W	S 42° E	N 86° W	S 59° W	S 71° W	S 56° W	S 72° W	S 73° W	S 68° W
84	S 86° W	S 52° W	S 23° E	S 81° W	S 53° W	S 67° W	N 10° E	N 70° E	S 65° W	N 79° W
85	S 79° W	S 81° W	S 16° W	S 87° W	S 66° W	S 89° W	N 84° W	S 83° E	N 77° W	N 84° W
86	S 81° W	S 55° W	S 8° W	S 81° W	S 56° W	W	S 74° W	N 86° E	S 81° W	S 79° W
87	S 84° W	S 46° W	S 12° E	S 80° W	S 51° W	S 89° W	S 56° W	S 45° E	S 78° W	S 56° W
88	N 68° W	S 57° W	S 15° E	S 68° W	S 57° W	N 80° W	W	S 52° E	S 89° W	S 80° W
89	S 74° W	S 37° W	S 1° E	N 35° W	S 59° W	N 89° W	S 82° W	S 82° E	S 72° W	S 76° W
Mean	S 84° W	S 47° W	S 14° E	S 78° W	S 50° W	S 86° W	S 86° W	S 27° E	S 77° W	S 75° W

Cloud.—The distribution of cloud during the cold weather months is very interesting. During the periods of high pressure which constitute the greater portion of the season, fine clear skies as a rule obtain both in the plains and hill districts. Whenever the weather begins to be disturbed, cirrus clouds begin to form and the amount of cloud increases until the sky is more or less covered with dense nimbus or pallio cumulus clouds. The average amount of cloud in these months hence reveals where cloud formation is most active and ascensional motion briskest at that period of the year.

The following table gives average cloud amounts for each month in different provinces :—

DISTRICT.	AVERAGE CLOUD AMOUNT IN			Average of period.
	December.	January.	February.	
Punjab	2.4	3.6	3.4	3.1
Sind	1.6	2.3	2.8	2.2
Rajputana	1.6	2.6	2.3	2.2
North-Western Provinces	1.7	2.5	2.6	2.3
Behar	1.9	2.2	2.4	2.2
Chutia Nagpur	2.0	2.3	2.0	2.1
Bengal	1.7	1.5	1.8	1.7
Central India	1.8	2.3	2.4	2.2
Central Provinces	1.8	1.8	1.9	1.7

The preceding data establish that—

1st—In Northern India cloud formation is most active during the cold weather in the Punjab and least active in Bengal.

2nd—The amount of cloud is greater in the Punjab than in any other province. It is also greater in the North-Western Provinces than in Sind, Rajputana or Central India.

3rd—The amount of cloud is less in the Central Provinces than in any other province of Northern and Central India except Bengal.

The following table gives the mean cloud amount of the months of December, January and February, at the hill stations in Northern and Central India and the nearest plain stations:—

Character of station.	STATION.	AVERAGE CLOUD AMOUNT IN			Average of period.
		December.	January.	February.	
{ Hill . . .	Murree	4'5	5'9	5'6	5'3
{ Plain . . .	Peshawar	3'3	4'9	4'3	4'2
	Rawalpindi	3'0	4'3	4'2	3'8
{ Hill . . .	Simla	3'4	5'5	4'5	4'5
{ Plain . . .	Ludhiana	2'8	4'1	3'9	3'6
{ Hill . . .	Chakrata	3'0	4'8	4'8	4'2
{ Plain . . .	Roorkee	2'0	3'5	3'4	3'0
{ Hill . . .	Ranikhet	2'3	4'1	4'4	3'6
{ Plain . . .	Bareilly	1'7	3'0	2'7	2'5
	Lucknow	1'7	2'9	3'0	2'5
{ Hill . . .	Darjeeling	4'1	5'6	5'7	5'1
{ Plain . . .	Dhubri	1'1	1'8	1'7	1'5
{ Hill . . .	Mount Abu	1'8	2'6	2'7	2'4
{ Plain . . .	Deesa	1'7	2'2	2'2	2'0
{ Hill . . .	Pachmarhi	2'1	2'3	1'9	2'1
{ Plain . . .	Jubbulpore	2'0	2'2	2'1	2'1

The hill stations in the Western Himalayas (from Murree to Kumaon) are very similarly situated with respect to the plains. The data indicate that the cloud amount decreases with approximate uniformity from Murree to Ranikhet at a rate of about 1 in 200 miles. The data also show that the amount of cloud at each of the Himalayan hill stations is greater than at the neighbouring plain stations by amounts which differ little from 1 and average 1'1 for the four stations in Upper India. The data for the two hill stations of Mount Abu and Pachmarhi prove that there is no such contrast between hills and plains in the lower mountain ranges of the interior of India. It is a peculiarity of the Himalayan area.

Finally, the only available data for a section across the Himalayas establish that the cloud amount increases from the plains of Upper India across the whole breadth of the Himalayas and is probably greater in the Upper Indus Valley than in the Himalayas. The following gives mean cloud data for the three stations of Simla, Kailang and Leh forming this section :—

STATION.	AVERAGE CLOUD AMOUNT IN			Mean of period, December to February.	Mean cloud amount, June to September.
	December.	January.	February.		
Simla	3'6	5'6	5'0	4'7	7'2
Kailang	4'9	6'9	6'0	5'9	5'7
Leh	5'3	6'5	6'7	6'2	4'8

All these facts tend to show that the Himalayan mountain barrier has a very powerful effect in determining the formation of cloud during the cold weather months and that the effect is greatest in the higher and not in the lower ranges, as is the case in the south-west monsoon.

An examination of the data of the plain stations affords equally interesting results.

The following table gives data for a series of representative stations along a line down the great Indo-Gangetic plain :—

STATION.	AVERAGE CLOUD AMOUNT IN			Mean of period.
	December.	January.	February.	
Peshawar	3'3	4'9	4'3	4'2
Sialkot	3'2	4'7	4'3	4'1
Lahore	2'0	3'4	3'5	3'0
Meerut	1'6	3'3	2'8	2'6
Bareilly	2'5	1'7	3'0	2'4
Lucknow	1'7	2'9	3'0	2'5
Allahabad	1'5	2'1	2'0	1'9
Patna	1'8	2'5	2'5	2'3
Berhampore	1'9	2'2	1'9	2'0
Dacca	1'4	1'6	1'8	1'6

The data in the preceding table establish that the amount of cloud decreases from the Upper Punjab to the eastern districts of the North-Western Provinces, then increases to Central Behar and decreases again eastwards to East Bengal. The fact that there is a minimum in the eastern districts of the North-Western Provinces and Oudh is of considerable importance as will be seen in the final discussion.

The following table gives the average amount of cloud for the months of December,

January and February along several lines of stations running southwards from the Himalayas :—

STATION.	AVERAGE CLOUD AMOUNT IN			Mean of period.	
	December.	January.	February.		
FIRST LINE .	{ Sialkot	3'2	4'7	4'3	4'1
	{ Lahore	2'0	3'3	3'4	2'9
	{ Mooltan	1'8	2'8	2'7	2'4
	{ Jacobabad	1'8	2'6	3'2	2'5
SECOND LINE .	{ Dehra	2'5	4'2	4'0	3'5
	{ Roorkee	2'2	3'4	3'3	3'0
	{ Meerut	1'7	3'2	2'0	2'5
	{ Delhi	1'9	3'7	3'0	2'9
	{ Jeypore	1'8	2'8	2'5	2'4
	{ Ajmere	1'4	2'3	2'3	2'0
	{ Pachpadra	1'6	2'2	2'1	2'0
{ Deesa	1'7	2'2	2'2	2'0	
THIRD LINE .	{ Bareilly	1'7	3'0	2'7	2'5
	{ Lucknow	1'8	2'8	2'9	2'5
	{ Agra	1'4	2'2	2'3	2'0
FOURTH LINE .	{ Gorakhpur	1'0	1'6	1'7	
	{ Allahabad	1'6	1'8	2'0	1'8
	{ Benares	1'6	2'1	2'1	
	{ Sutna	1'5	2'1	2'0	1'9
	{ Jubbulpore	1'9	2'2	2'1	
FIFTH LINE .	{ Durbhunga	1'1	1'4	1'6	1'4
	{ Purneah	1'2	1'4	1'2	1'3
	{ Patna	2'0	2'4	2'5	2'4
	{ Gya	1'8	2'0	2'2	2'0
	{ Hazaribagh	2'0	2'4	2'1	2'2
SIXTH LINE .	{ Dhubri	1'2	1'7	1'5	1'4
	{ Berhampore	1'9	2'2	2'0	2'1
	{ Burdwan	1'9	1'7	1'9	1'9
	{ Calcutta	1'9	1'4	1'9	1'7
	{ Saugor Island	2'2	1'7	2'0	2'0
SEVENTH LINE .	{ Sibsagar	4'2	5'4	5'6	7'6
	{ Silchar	2'9	3'1	3'1	3'0
	{ Dacca	1'4	1'6	1'8	1'6
	{ Chittagong	2'1	1'4	1'8	1'8

The estimation of cloud amount is made solely by eye observation, and hence is liable to be affected to some extent by the personal equation of the observer. The above means, however, harmonise so well together that they undoubtedly represent with approximate exactness the mean or normal cloud conditions of Northern and Central India during the cold weather.

The following conclusions result from the preceding data :—

1st—The cloud amount during the cold weather months in the Punjab, Oudh and the North-Western Provinces and in Assam decreases with distance from the Himalayas. The decrease is most regular in Upper India, and practically holds across the whole breadth of Upper India.

2nd—The mean cloud amount at this period is absolutely least along the foot of

the hills in Behar and North Bengal. The stations which have the least amount of cloud are—

STATION.	AVERAGE CLOUD AMOUNT IN			Mean of period.
	December.	January.	February.	
Gorakhpur	1'0	1'6	1'7	1'4
Durbhunga	1'1	1'4	1'6	1'4
Purneah	1'2	1'4	1'2	1'3
Dhubri	1'2	1'7	1'5	1'4

3rd—The data of the various sections across the Indo-Gangetic plain show that the cloud amount decreases eastwards to the eastern districts of the North-Western Provinces, and the northern district of Behar and thence increases eastwards in Central Behar and North Bengal and Assam. This central area of least cloud amount is defined by the following stations:—

STATION.	AVERAGE CLOUD AMOUNT IN			Mean of period.
	December.	January.	February.	
Gorakhpur	1'0	1'6	1'7	1'4
Durbhunga	1'1	1'4	1'6	1'4
Purneah	1'2	1'4	1'2	1'3
Allahabad	1'6	1'8	2'0	1'8
Ghazipur	1'4	1'9	1'5	1'6
Sutna	1'5	2'1	2'0	1'9

Rainfall.—The subject of the rainfall of India has been treated very fully in Mr. Blanford's valuable monograph on the subject, and it is only necessary to call attention to certain features in its distribution which are of great importance in considering the character and phenomena of the cold weather storms of India.

In India five-sixths at least of the rainfall is received during the south-west monsoon. The rainfall obtained from the humid winds of that season decreases rapidly in amount westwards and northwards from the North-Western Provinces and East Punjab, and is small in amount in the Indus Valley. The following data for representative stations in

Northern India enable the limits of the south-west monsoon rainfall to be determined with approximate accuracy :—

STATION.						Rainfall of period, June to October.
1st	{	Saugor Island	.	.	.	64.51
		False Point	.	.	.	58.08
		Gopālpur	.	.	.	41.50
2nd	{	Gorakhpur	.	.	.	44.32
		Allahabad	.	.	.	35.47
		Sutna	.	.	.	40.59
3rd	{	Delhi	.	.	.	24.26
		Jeypore	.	.	.	23.26
		Ajmere	.	.	.	20.51
4th	{	Peshawar	.	.	.	4.95
		Dera Ghazi Khan	.	.	.	4.39
		Jacobabad	.	.	.	3.03
5th	{	Quetta	.	.	.	1.47
		Peshin	.	.	.	0.65
		Kelat	.	.	.	1.18
6th	{	Bushire	.	.	.	...
		Baghdad	.	.	.	0.36

The following table gives a summary of the rainfall data for representative stations in North-Western India and the adjacent countries to the north-west for the two periods into which the year may be naturally divided in Southern Asia, *viz.*, from November to May and from June to October :—

PROVINCE.	STATION.	POSITION.		Average Rainfall of period, Nov- ember to May. a.	Average Rainfall of period, June to October. b.	Ratio of rain- fall, b to a.
		Latitude N.	Longitude E.			
ASIATIC TURKEY	Baghdad	33°19'	44°26'	9.88	0.36	0.04
PERSIA	{ Bushire	28°59'	50°49'	13.89	...	0
	{ Teheran	35°40'	51°22'	10.61	0.86	0.08
	{ Samarkhand	39°56'	66°50'	11.67	1.14	0.1
TURKESTAN	{ Tashkend	41°30'	68°52'	11.36	1.59	0.1
	{ Margelan	41°40'	71°12'	3.81	1.41	0.4
	{ Peshin	30°23'	66°40'	7.96	0.65	0.1
BELUCHISTAN	{ Kelat	29°0'	66°25'	7.29	1.18	0.2
	{ Quetta	30°11'	67° 3'	7.73	1.47	0.2
	{ Jacobabad	28°24'	68°18'	1.21	3.03	2.5
SIND AND RAJPUTANA	{ Pachpadra	25°55'	72°18'	0.63	9.57	15.0

The data of the preceding two tables show clearly that the mountains on the north-west frontier form a natural line of separation between the area to the east in which the rainfall is received chiefly during the south-west monsoon period, *i.e.*, May to October, from the area to the west in which the rainfall is very small in amount or *nil* during that period, whilst moderate rain is received during the other period of the year, *viz.*, from November to May.

It will simplify the statement if we refer to these two periods as the periods of summer and winter rainfall in Southern Asia.

The following table giving mean monthly rainfall data for the preceding stations named in the preceding table shows more fully and clearly the distribution of the rainfall during the year:—

Average Monthly and Annual Rainfall.

DISTRICT.	REPRESENTATIVE STATION.	J.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
TURKEY (Asiatic).	Baghdad . . .	0'52	2'75	2'00	1'86	0'22	0'01	...	0'35	...	...	0'32	2'21	10'24
PERSIA . . .	{ Bushire . . .	3'51	3'38	0'72	0'74	...	...	...	...	...	...	1'65	3'89	13'89
	{ Teheran . . .	2'06	2'73	1'54	1'53	0'86	0'28	0'01	0'06	0'04	0'47	0'75	1'14	11'64
TURKESTAN . . .	{ Samarkhand . . .	1'30	1'89	2'34	3'53	0'75	0'18	0'04	0'02	0'03	0'87	0'44	1'42	13'42
	{ Tashkend . . .	1'94	0'93	2'73	2'79	0'90	0'40	0'02	0'02	0'22	0'93	0'73	1'34	12'94
	{ Margelan . . .	0'81	0'32	0'20	0'81	0'77	0'38	0'08	0'02	0'17	0'76	0'23	0'67	4'21
BELUCHISTAN . . .	{ Peshin . . .	3'19	1'52	1'78	0'75	0'42	...	0'23	...	...	...	0'28	0'44	8'61
	{ Kelat . . .	1'77	1'99	2'05	0'56	0'27	0'05	0'45	0'60	0'01	0'07	0'31	0'34	8'47
	{ Quetta . . .	2'02	1'70	2'05	1'11	0'42	0'10	0'64	0'46	0'19	0'08	0'04	0'39	9'20
SIND . . .	{ Kurrachee . . .	0'69	0'26	0'15	0'17	0'05	0'18	2'95	1'70	0'80	0'06	0'07	0'17	7'25
	{ Jacobabad . . .	0'26	0'26	0'31	0'16	0'13	0'07	1'31	1'33	0'24	0'01	0'07	0'09	4'24
RAJPUTANA . . .	{ Bickaneer . . .	0'27	0'22	0'11	0'18	1'30	1'90	3'51	3'02	1'22	0'09	0'07	0'02	11'91
	{ Pachpadra . . .	0'41	0'10	0'08	...	0'66	0'70	2'87	3'39	1'90	0'05	...	0'04	10'20

A second point of great importance is that, although the summer rainfall is most important on the plains and lower hills, it gradually decreases in importance with elevation in the Himalayan mountain area and it is almost certain that at the first and second lines of snow the winter precipitation is larger and more important than the summer rainfall. The following table gives data in confirmation of the statement. The stations are arranged in groups, each group consisting of one or more plain stations and of the hill stations nearest to these plain stations:—

Number of Group.	Character of station.	STATION.	Number of years data from which averages are obtained.	Average winter Rainfall.	Average summer Rainfall.	Ratio.
1	{ Plain .	Rawalpindi .	31	10'27	22'03	2'2
	{ Hill .	Murree . . .	14	16'48	38'31	2'6
2	{ Plain .	Ludhiana . .	33	5'85	25'43	4'3
	{ Hill .	Simla . . .	27	12'76	56'87	4'4
	{ Hill .	Kilba . . .	7	30'33	23'85	0'8
	{ Hill .	Kailang . . .	6	13'72	7'01	0'5
3	{ Plain .	Roorkee . . .	35	5'34	37'24	7'0
	{ Hill .	Mussoorie . .	36	11'00	84'39	8'0
	{ Hill .	Chakrata . .	20	10'95	50'57	5'0

Number of Group.	Character of station.	STATION.	Number of years data from which averages are obtained.	Average winter Rainfall.	Average summer Rainfall.	Ratio.
4	Plain .	Bareilly .	41	3'08	38'81	13'0
	Plain .	Moradabad .	41	3'75	36'51	10'0
	Hill .	Nainital .	39	11'15	80'86	7'5
	Hill .	Ranikhet .	18	8'50	40'84	5'0
	Hill .	Almora .	45	7'37	32'10	4'3
	Hill .	Pithoragarh .	25	8'47	40'75	5'0
5	Plain .	Purneah .	19	3'04	61'12	20'0
	Plain .	Jalpaiguri .	20	6'89	121'37	17'0
	Hill .	Darjeeling .	31	8'46	112'11	13'0
	Hill .	Pe d ong .	5	10'82	89'73	8'3
	Hill .	Gnatong .	1	23'12	146'31	6'3

The more important facts established by the preceding data, more especially the data for the second and fourth groups of stations are that the winter rainfall is relatively greater than the summer rainfall in the hills than in the plains, and its importance increases very rapidly with distance from the plains (and probably altitude), and in the cases of Kilba and Kailang, which are near and just beyond the first line of snows, the winter rainfall is actually greater than the summer, though in the outer ranges the latter is from three to five times as large as the former.

It is a well-known fact that in the Western Himalayas little snow or rain is received on the higher elevations during the summer period, and that nearly the whole of the snow is due to precipitation in the winter season.

The distribution of the winter rainfall in the plains of Northern India is characterised by two very important features:—

1st—It decreases in amount eastwards from the North Punjab to Behar.

2nd—It decreases in amount southwards from the Himalayas.

The following gives data in illustration of the first feature:—

STATION.	Normal rainfall of period, November to February.
Rawalpindi	6'32
Lahore	2'46
Meerut	2'18
Cawnpore	1'46
Lucknow	1'59
Allahabad	1'62
Benares	1'53
Patna	1'57
Bhagalpur	1'46

In Bengal and to some extent in Behar the rainfall in March and sometimes in February is in part due to cold weather storms and in part to hot weather storms, *i.e.*, storms due to local thermal disturbance, and in Bengal in November it is occasionally due

to cyclonic storms approaching it from the Bay. The data given above are for stations about the same distance from the hills during the period, November to February, when the rainfall is almost solely due to cold weather conditions. They show clearly the diminution of winter rainfall eastwards from the North Punjab to Behar.

The second feature is illustrated by the following statement of rainfall in four lines of stations running southwards from the Himalayas:—

LINE.	Stations across Line.	Normal rainfall of period, December to February.
FIRST LINE	Gurdaspur	4'82 inches.
	Amritsar	3'18 "
	Labore	2'32 "
	Montgomery	1'27 "
SECOND LINE	Dehra Dun	4'73 "
	Roorkee	3'84 "
	Meerut	2'12 "
	Delhi	1'94 "
	Ulwar	1'33 inches.
	Jeypore	0'92 "
THIRD LINE	Ajmere	0'85 "
	Bahraich	2'03 "
	Gonda	1'52 "
	Fyzabad	1'44 "
	Sultanpur	1'25 "
	Partabgarh	1'36 "
	Allahabad	1'41 "
	Durbhunga	1'27 "
FOURTH LINE	Motihari	0'98 "
	Sewan	1'48 "
	Patna	1'36 "
	Gya	1'49 "
	Hazaribagh	1'52 "

The data of the first and second lines show very clearly the fact that the winter rainfall, from November to February, decreases steadily from the Himalayas southwards. In Behar and the eastern districts of the North-Western Provinces it decreases for some distance, and then is practically unchanged in amount.

Another minor feature that it may be, however, interesting to note is that the winter or cold weather rainfall frequently continues in March in Upper India, whilst the rainfall due to hot weather storms usually commences in March in Bengal and extends westwards and increases in amount in April. The driest area in March and April in Northern India

is hence the intermediate area of West Behar and the eastern half of the North-Western Provinces. This is shown by the following data for a few representative stations :—

STATION.	Total average rainfall from December to February.	Total average rainfall from December to April.	Ratio.
Lahore	2'35	3'90	1'7
Sirsa	1'39	2'26	1'6
Delhi	1'93	3'01	1'5
Meerut	2'12	3'21	1'5
Lucknow	1'56	1'98	1'2
Azamgarh	1'20	1'70	1'2
Arrah	1'73	2'73	1'5
Purneah	1'24	3'04	2'5
Dinagapore	1 18	4'24	3'6

Hence we have the following conclusions :—

1st—The south-west monsoon gives no rain to Persia and very little to Afghanistan and Beluchistan, and that almost exclusively to the eastern districts. The Suleiman and other mountains of the north-west frontier form the natural boundary of the south-west monsoon rainfall area in the north-west as the Himalayan chain (at least in the western portion) does on the north.

2nd—The south-west monsoon rainfall is heaviest on the plains and lower mountains of the Himalayan region up to an elevation of, perhaps, 3,000 or 4,000 feet, and above that elevation it decreases rapidly with elevation and distance from the plains. It is of comparatively little importance beyond the first and second line of snowy peaks in the Western Himalayas.

3rd—On the other hand, the winter precipitation, which is small in amount in the plains of Upper India, increases rapidly with elevation in the Western Himalayas, and is almost certainly the chief source of the snows. It is hence probable, as will be shown later on, that the average winter snowfall in the interior is not less than forty feet per annum, which is received almost entirely during the winter half of the year.

Brief statement of the meteorology of the countries to the north-west of Upper India.

The following gives a very brief summary of certain points in the meteorology of Persia, Afghanistan and Turkistan, which appear to throw light upon the meteorology of India in the cold weather months.

In Persia winds are almost solely from the directions north-west and south-east. The north-west winds are necessarily the colder of the two. Rain falls chiefly during the prevalence of south-east winds, and the north-west winds only give rain in the Persian Gulf when they follow south-east gales. Hence rain falls chiefly during cyclonic storms travelling eastwards, the rainfall occurring to the north and east of the storm area as in India. Rain rarely falls between May and October. Over the greater part of the country (including the whole of the plateau of Iran) the rainfall is less than 10 inches, and over the greater part of Central and South-East Persia and Beluchistan the annual rainfall

does not exceed 5 inches. Cultivation is mainly carried on by irrigation from the rivers which are fed chiefly by the snow that falls on the higher elevations during the winter.

In Afghanistan the winds are chiefly from the north-west. The winter is very severe in the north. Snow usually lies two or three months in Kabul, and at Ghazni it has been known to lie until nearly the end of March. At Herat north-west winds blow with great violence from May to September, but the weather is comparatively open and fine during the winter. Over the greater part of Afghanistan the weather in December, January, February and March is very cold and skies more or less clouded, and much rain or snow falls. The barometer falls rapidly before the commencement of heavy snow, and winds shift from north to south during each large storm. The heavier snow-storms are almost invariably followed by a wave of great cold. It is hence almost certain that snow falls during cyclonic storms which march eastwards. The temperature rises rapidly from March. In April thunderstorms with hail are by no means infrequent. From May to September hot dry weather with very strong westerly winds prevails.

In Turkistan the cold is usually very severe in winter, and it rains and snows at short intervals heavily in the mountains to the east and south. In the plains and steppes the rainfall is on the other hand very scanty. Thus, at Tashkend (at the base of the mountains), the average annual rainfall is only 13 inches, whilst in the steppes of the Lower Amu the fall is said to be less than three inches. To the south of Khojend the most striking feature in the weather is the almost entire absence of rain. Thus the mean annual rainfall of Margelan in the centre of this area is 5.22 inches, or practically the same as that of the driest stations in Sind, *e.g.*, Rohri (5.29 in ches) and Shikarpur (4.61 inches).

Hence the preceding remarks show that over the whole of the lower plateaux and plains of Arabia, Persia, Turkistan, Afghanistan and Beluchistan very little rain falls, the average rainfall probably not exceeding five or six inches, and hence about the same in amount as that of Sind and West Rajputana (Jeysulmere, Jodhpur, Marwar, Bikaner, etc. In the higher mountain ranges of East Persia, South-East Turkistan, North Beluchistan and Afghanistan, which range in height from 15,000 to 28,000 feet, heavy snowfall is received during the winter months, and the rivers are chiefly maintained by the melting of the snow and of the glaciers.

There is very little exact meteorological information for any part of this area to the north-west of India extending from about 25° N. Lat. to 35° or 40° N. Lat.

The following mean data for a small number of stations in North-Western India, and the adjacent countries to the west and north-west of India, are taken from the Annual Reports on the Meteorology of India and the publications of the St. Petersburg Weather Bureau of the few meteorological observatories at which systematic observations have been taken for several years.

The data were obtained for use in the preparation of this paper and are given for reference.

Average monthly mean temperature of ten stations in North-Western India and adjacent countries.

COUNTRY.	STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
PERSIA.	Bushire	57.2	57.5	62.7	71.4	80.8	84.7	88.1	88.7	85.1	77.8	69.2	61.1	73.9
	Teheran	35.6	38.1	49.3	58.1	69.4	73.2	76.5	75.2	67.8	62.2	52.2	43.5	58.4

COUNTRY.	STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
TURKISTAN	Samarkhand.	34.0	30.7	47.3	58.5	70.3	78.1	79.2	76.8	67.3	54.9	46.0	38.3	56.7
	Tashkend.	31.8	31.5	48.0	59.4	71.4	79.5	82.6	79.7	67.3	54.7	44.6	37.4	57.4
	Margelan.	28.2	28.4	45.9	62.2	71.2	80.2	82.8	81.1	68.9	54.0	42.8	33.1	56.8
BELUCHISTAN	Quetta.	39.5	40.0	49.9	57.9	66.2	73.8	77.4	75.2	66.9	55.8	46.2	41.1	57.5
SIND	Kurrachee.	64.9	68.0	76.0	80.0	85.2	86.8	84.1	81.9	81.8	79.6	72.6	67.3	77.4
	Jacobabad.	57.2	61.6	74.0	83.3	92.0	96.2	94.1	90.8	87.8	78.3	65.4	58.4	78.3
RAJPUTANA	Bickaneer.	60.4	63.7	77.3	87.3	93.5	94.7	89.8	87.4	87.5	83.6	71.3	62.7	79.9
	Pachpadra.	60.9	64.1	76.3	85.3	91.6	92.1	86.5	83.7	84.1	80.6	68.6	62.2	78.0

Average direction and steadiness of wind of ten stations in North-Western India and adjacent countries.

COUNTRY.	STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
PERSIA	Bushire.	31N 8°W	32N18°W	38N47°W	40N63°W	55N56°W	70N57°W	82N72°W	60N71°W	53N51°W	46N35°W	37N 9°W	33N 5°E	44N46°W
	Teheran.	12N22°E	22N31°E	15N38°W	11N53°W	14S 65°W	71S 12°W	22S14°E	18S 25°E	19S 3°E	18S 42°E	2S 31°W	18S 8°E	3S 14°E
TURKISTAN	Samarkhand.	13S 6°E	15S 24°E	24S 50°E	16S 27°E	15S 16°E	15S 39°E	15S 60°E	18S 81°E	18S 77°E	17S 50°E	20S 55°E	13S 57°E	15S 43°E
	Tashkend.	20N56°E	24N38°E	31N24°E	19N 7°W	13N20°E	16N	16N11°W	16N21°W	13N22°W	23N 5°E	29N24°E	33N33°E	20N15°E
	Margelan.	25S25°E	20S 8°E	15S 8°W	10S27°W	10S28°W	21S 53°W	23S71°W	23S 64°W	20S20°W	19S23°W	17S 3°W	11S 8°E	15S25°W
BELUCHISTAN	Quetta.	27N83°W	30N78°W	36S 65°W	32N81°W	51N69°W	43N69°W	34	42N78°W	50N58°W	50N56°W	46N41°W	37N48°W	37N69°W
SIND	Kurrachee.	17N23°W	27N80°W	64S69°W	80S 62°W	85S 60°W	85S 58°W	83S 62°W	81S 63°W	83S 62°W	64S 67°W	18S 81°W	14N42°E	50N86°W
	Jacobabad.	27N10°W	36N17°E	26N67°E	18S 84°E	17S 61°E	46S 31°E	56S 45°E	54S 50°E	41S 36°E	11S 47°E	16N12°W	22N15°W	17S 72°E
RAJPUTANA	Bickaneer.	8S75°E	5N26°W	18S 56°W	37S 60°W	45S72°W	62S 48°W	36S 31°W	49S 35°W	38S 47°W	41S 61°W	14S 45°W	15N74°E	26S 54°W
	Pachpadra.	21N58°E	10N58°E	19S 40°W	46S 47°W	68S 44°W	81S 39°W	66S 33°W	74S 39°W	56S 45°W	17S 36°W	29N57°E	23N50°E	33S 36°W

Average monthly mean relative humidity of ten stations in North-Western India and adjacent countries.

COUNTRY.	STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
PERSIA	Bushire.	62	70	68	64	60	63	64	66	65	63	66	71	65
	Teheran.	72	71	57	57	48	49	49	47	50	52	63	73	64
TURKISTAN	Samarkhand.	79	76	66	70	60	47	45	46	52	61	65	76	62
	Tashkend.	69	66	63	65	55	44	40	43	45	53	59	61	55
	Margelan.	81	78	68	65	59	47	43	41	50	68	74	80	61
BELUCHISTAN	Quetta.	67	66	57	50	42	42	49	45	38	43	48	55	50
SIND	Kurrachee.	56	57	66	68	74	74	78	78	76	64	55	56	67
	Jacobabad.	47	39	40	36	34	42	53	57	54	45	45	47	45
RAJPUTANA	Bickaneer.	37	38	36	32	33	40	51	57	55	41	34	34	41
	Pachpadra.	44	31	33	34	42	51	66	68	61	42	34	40	46

Average proportion of clouded sky of ten stations in North-Western India and adjacent countries.

COUNTRY.	STATION.	January.	February.	March.	April.	May.	June.	July.	August.	September.	October.	November.	December.	Year.
PERSIA .	Bushire .	Not recorded.												
	Teheran .	4.9	5.3	4.3	4.2	3.1	1.3	0.9	1.2	1.5	1.6	3.8	4.1	3.0
TURKISTAN .	Samarkhand .	5.6	4.8	5.2	5.6	2.8	1.2	0.6	0.3	1.1	2.5	3.0	5.6	3.1
	Tashkend .	6.2	5.2	5.1	5.3	2.8	1.6	1.3	0.6	2.0	3.3	3.7	5.3	3.6
	Margelan .	5.6	6.1	5.3	5.9	4.3	3.2	2.6	1.4	1.9	3.8	4.1	6.5	4.4
BALUCHISTAN .	Quetta .	4.4	4.3	4.5	3.6	1.9	1.0	1.6	1.5	0.5	0.4	0.8	3.0	2.3
SIND .	Kurrachee .	2.6	3.0	3.1	2.1	2.1	4.4	7.2	6.9	4.4	1.0	1.2	1.9	3.3
	Jacobabad .	2.6	3.2	3.2	2.8	1.3	0.9	2.2	2.2	0.7	0.4	0.9	1.8	1.8
RAJPUTANA .	Bickaneer .	3.4	3.6	3.5	2.9	2.5	2.8	5.7	6.0	3.4	1.4	0.8	2.3	3.2
	Pachpadra .	2.2	2.1	2.0	1.5	1.6	2.9	6.2	6.2	3.4	1.2	0.6	1.6	2.6

CHAPTER II.

History of the Cold Weather Storms of the period 1876-91.

The accounts of the cold weather storms of the first three years of the period under discussion (*vis.*, 1876-1879) are necessarily meagre, as the number of observatories was much smaller than at present, and the observations were in many cases unsatisfactory, and also the preparation of daily charts based on the observations was not commenced until the year 1877. These three years were years of exceptional abnormal weather conditions in India. They included the period of the Madras famine of 1876-77 and of severe drought in the North-Western Provinces in 1877-78, and hence it appeared to be desirable to give in a brief form at least an account of the storms of the cold weather periods of these years.

1875-76.

Chief abnormal features of the meteorology of India in 1875.—The cold weather of 1874-75 was drier than usual. March and April were very hot and dry months. The rains set in over Bengal about the 11th of June and extended slowly westwards. They were established in Upper India in the first week of July. The Central Provinces, Chota Nagpur and Orissa had very heavy rain in June and July, whilst North and East Bengal, the North-Western Provinces and the Punjab received less than the normal. The rainfall was fairly well distributed in August, and was abundant, although even more irregularly distributed than usual, in September. The monsoon currents withdrew from North-Western India at the end of September.

Bengal received light to moderate rain in October, and Orissa a very heavy burst of rain. The rainfall of the period, October to December, was abundant throughout Madras. Hence the chief features of the rainfall of the south-west monsoon of 1875 were—

1st.—Abnormally excessive rainfall in the Punjab and Rajputana, due almost entirely to heavy precipitation in the months of August and September. The

rainfall in these two areas was the highest recorded during the 20 years, 1855-75.

2nd.—The rainfall was in moderate excess in the North-Western Provinces, Central India, the Central Provinces, Berar, Guzerat, Khandesh and the Konkan.

3rd.—The rainfall was more or less in defect in the greater part of Bengal, the deficiency being most marked in North Bengal.

4th.—The rainfall of the whole season was in moderate excess in Burma and Madras; and the rains of the retreating south-west monsoon were generally very favourable in Madras.

The preceding remarks hence give the chief features of the distribution of the rainfall of the south-west monsoon of 1875.

The mean pressure of the Indian area differed little from the normal in November and December 1875. Pressure was very considerably in defect in January, February and March 1876, and, so far as can be judged from the somewhat doubtful returns of two hill stations, pressure was less in defect at the hill than at the plain stations.

The following brief sketch of the chief features of the weather during January to May 1876 is taken from Mr. Blanford's monograph on "The Rainfall of India":—

"Except on the North-West Himalayas, and chiefly between March and May, at a few stations along their foot, the first months of the year were generally dry. On the plains of the North-Western Provinces, and a large part of the Punjab, there was little or no rain in January or February, and in the former only slight and infrequent showers from March to May. On the Punjab plains, any fall in January was slight, and restricted to the vicinity of the hills; and that of February but little less so in both months almost everywhere below the average; but that of March was about equal to it; and, except in the extreme south and west of the province, that of April was excessive, and especially so on the hills. In May, the rainfall on the North-West Himalayas was about the usual amount.

"In Rajputana there was very little rain before May, and even then no general rain. Berar, the Central Provinces, and the peninsular districts of Bombay, excepting Dharwar, were almost absolutely rainless during the first five months; and in Madras, except locally, there was less than the usual amount. In Bengal and Assam there was no rain in January and very little in February. In March and April the deficiency was only partial; and in May there was more than the average fall in the eastern and northern districts.

"The winter rainfall of Northern India failed therefore almost completely, but the spring precipitation on the North-West Himalayas was on the whole equal to an average fall, though not so on the plains."

There were no well-defined cold weather storms during the cold weather period of 1875-76. The following were the chief periods of irregular disturbance:—

(I) *From the 6th to the 8th January 1876.*—The Punjab and Sind obtained light local showers during the period. Little or no rain fell in the North-Western Provinces, Bihar or Rajputana. It was in fact a slight disturbance affecting only Upper India.

(II) *From the 15th to the 17th January 1876.*—The rainfall, due to this disturbance, was light and restricted as in the previous storm to Upper India.

February was rainless over the greater part of the Punjab as in the North-Western Provinces, Rajputana and Central India. There were several light disturbances in March, chiefly, so far as can be judged, of the hot weather type. The cold weather period of December 1875 to March 1876 was hence remarkable for the absence of storms in the

plains and for very deficient rainfall. The following data for a few stations in Upper India illustrate this feature:—

STATIONS.	RAINFALL IN INCHES.				
	December 1875.	January 1876.	February 1876.	Actual of period.	Normal of period
Leh	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	0'54
Peshawar	0'70	2'20	0'80	3'70	3'44
Murree	1'95	<i>Nil</i>	1'19	3'14	7'40
Lahore	0'30	0'06	0'13	0'49	2'29
Simla	0'85	0'67	2'6	4'18	6'61
Mooltan	0'16	0'23	0'35	0'74	0'91
Delhi	<i>Nil</i>	0'03	<i>Nil</i>	0'03	1'83
Roorkee	<i>Nil</i>	0'20	0'10	0'30	3'87
Naini Tal	<i>Nil</i>	0'60	0'10	0'70	7'02
Agra	1'10	<i>Nil</i>	<i>Nil</i>	1'10	1'05
Ajmere	0'93	<i>Nil</i>	<i>Nil</i>	0'93	0'78
Jacobabad	0'07	0'20	0'02	0'29	0'58

The preceding data indicate very clearly that the rainfall was abnormally light, except in some parts of the most northern districts of the Punjab and adjacent hills. The following remarks from Mr. Blanford's Report on the Meteorology of India in 1876 show that untimely snow fell in the North-Western Himalayas in March and April:—

"In the early months of the year the rainfall was unusually copious over the North-West Himalayas and the plains of the Punjab which border the foot of the mountains; and, indeed, on the North-West Himalayas the rainfall was above the average, more or less, throughout the greater part of the year. This rain on the outer hills is most frequently accompanied by snow on the main and higher ranges; and, indeed, when I visited Rawalpindi in the early part of April 1876 I was informed that snow lay in some thickness at Murree—a very unusual occurrence so late in the season; and the slopes of the Pir Panjal were snowed down to a low level."

1876-77.

Chief abnormal features of the meteorology of India in 1876.—The preceding remarks have shown that the winter rains failed almost entirely in North-Western India during the cold weather period of 1875-76. The succeeding hot weather was, on the whole, drier and hotter than usual. Pressure was more or less below the normal over nearly the whole Indian area; but relatively to the general condition there was a remarkable local excess in the Deccan and Western India, whilst there was a moderate deficiency in Northern and North-Eastern India.

An important feature of the period from January to May 1876 was that, although the winter rainfall in the plains of Northern India was unusually limited in amount, there was a heavy local precipitation in the more northerly districts of the Punjab and in the adjacent mountain areas. This excessive precipitation was even more marked in March and April than in the preceding months. Thus it is stated that in April 1876 the Pir Panjal was snowed down to a very low level, and that snow in some thickness was lying at Murree—a most unusual occurrence. This local and untimely snowfall in the

Afghan mountains and Kashmir Himalayas exercised an important effect on the subsequent weather.

The rains set in rather earlier than usual in Bengal. They were considerably delayed on the West Coast, and the rainfall of June was very considerably below the normal in Western India. The rains were very irregularly distributed in July and August in Northern India and were very deficient in the Deccan and Mysore. They retreated from Upper India about the normal date. The rainfall of September was very light in Upper India. It was normal or in excess in North-Eastern India and the Central Provinces, but was very deficient in the Deccan, Mysore and the Carnatic.

In October, Bihar and Bengal received much heavier rain than usual. Slight disturbance of the cold weather type gave light rain in the Punjab during November. The retreating south-west monsoon rains failed almost completely over the greater part of the Deccan, Carnatic and Mysore in November and December. The chief features of the rainfall of the south-west monsoon of 1876 were hence the following:—

1st.—The rainfall was normal or in slight to moderate excess in the North and West Punjab, Rajputana, Central India and the greater part of Bengal and Chota Nagpur.

2nd.—There was a considerable deficiency in the North-Western Provinces.

3rd.—The rainfall was very deficient over nearly the whole of the Peninsula, and especially in Mysore and a large portion of the Deccan. There was in fact a more or less complete failure of the rains which led to the Madras famine of 1876-77.

The following statement gives comparative rainfall data of the south-west monsoon of 1876:—

DIVISION.	VARIATION FROM NORMAL OF	
	Ordinary south-west monsoon rainfall June to September 1876.	Retreating south-west monsoon rainfall October to December 1876.
	Inches.	Inches.
Punjab Plains	—0'12	+0'51
North-Western Provinces and Oudh	—4'30	+0'39
East Rajputana	+1'72	—0'60
Central India	+7'60	—4'50
Bihar	—0'80	+1'65
Lower Bengal	—3'32	+0'51
Assam	—1'60	+0'81
Central Provinces	—1'92	—2'01
Berar	—4'40	—2'70
Bombay	—2'40	—2'22
Hyderabad	—8'52	—3'81
Konkan, Malabar and Ghats	—14'08	—7'50
Mysore and Bellary	—6'20	—7'30
Burma	—8'80	—2'91

Pressure was considerably in excess in the Indian area during the cold weather period of 1876-77. The following gives data:—

October 1876.	. . + '033"	December 1876	. . + '035"
November "	. . 0	January 1877	. . + '058"
February 1877	. . + '037"		

So far as can be judged there were no very marked pressure peculiarities, except that pressure was relatively in defect at Leh as compared with the Punjab. The following gives the difference of the pressure variations of Leh and Murree and neighbouring plain stations:—

	VERTICAL PRESSURE ANOMALY.					
	October 1876.	November 1876.	December 1876.	January 1877.	February 1877.	March 1877.
Leh minus Lahore	—'075	—'069	—'018	+ '005	—'018	—'041
Murree minus Peshawar . . .	—'034	—'006	+ '021	—'005	—'006	+ '013

The preceding data hence show that there was a slight persistent deficiency of pressure at the higher stations which was first shown in October at the termination of the rains.

The following extract from Mr. Blanford's monograph on "The Rainfall of India" gives a brief sketch of the cold weather of 1876-77:—

"In respect of the rainfall, the cold weather season of 1877 was strikingly abnormal. January and February were remarkably wet months in nearly all parts of Northern India; as also had been the preceding October and November in the most northern province, and especially on the North-West Himalayas. In March, April and May the fall was, on the whole, quite up to the average, April being especially wet on the North-West Himalayas and in the Punjab, and May in all parts of the Himalayas and Bengal. On the first of these tracts the fall was from one to upwards of three inches above the average in every one of the first five months of the year; and on the Sikkim Himalayas from $\frac{1}{2}$ to $1\frac{1}{2}$ inches above it in January, April and May."

The following extract from the narrative report of Mr. E. C. Ryall, in charge of the Kumaun and Garhwal Party of the Topographical Survey, gives some interesting facts respecting the snow accumulation due to the numerous storms of the period:—

"The winter of 1876-77 proved to be the severest known for many years past among these hills; the spring was wet and cold and felt quite wintry. When I left Dehra Dun I was in hopes that the wet weather would not last long; it continued however with few intermissions till the 8th June, the most noticeable break up to that time being from the 9th up to the 17th April. * * * Mountains which in ordinary years had their snow line at the end of April at an elevation of 12,000 feet above sea-level were mantled with snow down to 9,000 feet; and valleys which at that time of year used to be clear of all snow up to 10,000 feet were literally choked with snow down to 6,000 feet, this accumulation in the valleys being caused by snow drifts and avalanches from the mountain sides."

Storms of the cold weather period of 1876-77.—The cold weather of 1876-77 was characterized by frequent storms in Northern India and by excessive snowfall in the Western Himalayas. The following gives an account of the more important storms, *viz.*, storm of the 11th to the 14th January, of the 15th to the 18th January, of the 28th to the 31st January, of the 2nd to the 8th February, and of the 20th to the 23rd February. One noteworthy feature of this stormy cold weather season was that the preceding months of November and December 1876 were practically free from storms in Upper India.

(I) *Storm of the 11th to the 14th January 1877.*—This was a well-defined cold weather storm. It gave general rain to the Punjab on the 11th and 21th, the North-Western Provinces and Bihar on the 12th and 13th, Bengal and Assam on the 13th and 14th, and light local showers to the Central Provinces on the 11th, 12th and 13th. The following gives a summary of the average total rainfall due to the storm:—

PROVINCE.	Average total rainfall 7th to 14th January 1877.
	Inches.
Punjab	1'30
North-Western Provinces	1'60
Oudh	2'00
Bengal	1'34
Assam	1'09
Central Provinces	0'15

Rainfalls exceeding 2 inches in 24 hours were received at a large number of stations in Northern India during the storm. The following were the most noteworthy:—

DIVISION.	District.	Station.	Date.	Amount in inches.
PUNJAB	Kangra	Nurpur	11th . .	3'70
	"	Palampur	11th . .	3'50
	Ludhiana	Samrala	12th . .	3'40
	Jullundur	Nawashahr	11th . .	3'20
NORTH-WESTERN PROVINCES	Moradabad	Moradabad	12th . .	3'60
	Basti	Basti	12th . .	3'70
	"	Domariaganj	12th . .	5'50
	Kumaun	Naini Tal	11th . .	4'30
OU DH	Kheri	Kheri	13th . .	3'30
BENGAL	Bhagalpur	Naya Dumka	13th . .	2'80
ASSAM	Khasi and Jaintia Hills	Jowai	13th . .	2'80
CENTRAL PROVINCES	Sambalpur	Bargarh	13th . .	1'37

This disturbance apparently consisted of a shallow depression which advanced eastwards across Northern India and of a deep secondary depression in the East and South-East Punjab. The fall of the barometer at Murree and Lahore, due to the secondary depression, was nearly four-tenths of an inch, and that due to the primary at Ranikhet, Bankipore and Calcutta was little more than a tenth. Temperature decreased rapidly in Northern India after the passage of the storm. The primary depression travelled across Northern India in about four days, and hence at a rate of between 300 and 400 miles per diem. The secondary depression formed and disappeared in less than 72 hours. It,

hence, was a storm typical of its class. The precipitation due to the storm was unusually great, more especially in the Punjab.

(II) *Disturbance of the 15th to the 18th January 1877.*—This was a very slight disturbance, which gave light showers in the Punjab and North-Western Provinces. The depression was very small in amount, and it hence does not come within the category of cold weather storms according to the definition adopted in the first chapter.

(III) *Storm of the 31st January 1877.*—This was also a small disturbance. It appeared in North-Western India on the 28th and passed eastwards through Rajputana on the 29th, to the south of Allahabad on the 30th, and through South Bihar and West Bengal on the 31st. There was a slight tendency towards the establishment of a secondary depression in the Punjab on the 29th, but it did not pass beyond the initial stage. The Punjab received general rain on the 28th, but the falls were, except in a few cases, light.

(IV) *Disturbance of the 2nd to the 8th February 1877.*—This appears to have consisted of two depressions which followed each other rapidly across Northern India, each of which gave rise to a deepish secondary depression in the Punjab. The following gives the barometric changes at typical stations in Northern India during this period:—

STATION.	PRESSURE CHANGES IN 24 HOURS ENDING 10 A.M. OF						
	2nd.	3rd.	4th.	5th.	6th.	7th.	8th.
Jacobabad	—'115	—'210	+ '123	—'040	—'004	—'036	+ '248
Peshawar	—'071	—'172	—'047	+ '146	—'040	—'205	+ '446
Murree	—'015	—'116	+ '010	+ '026	—'040	—'212	+ '252
Lahore	—'020	—'238	+ '050	+ '088	—'088	—'228	+ '374
Roorkee	+ '005	—'082	—'015	+ '009	+ '025	—'203	+ '274
Allahabad	+ '001	—'069	—'077	+ '045	+ '057	—'059	+ '052
Bankipore	+ '013	—'004	—'060	—'024	+ '054	+ '053	—'031
Calcutta	+ '010	+ '002	+ '099	+ '036	+ '042	—'012	+ '020

A comparison of these changes of pressure indicate that the disturbance consisted, as stated above, of two primary depressions, the first of which gave rise to a feebleish secondary depression, and the latter to a deep secondary depression. The barometric data also show that the first primary depression was much deeper and more extensive than the second. The rainfall was in strict accordance with this assumption of the formation of two secondary depressions, of which the second was the deeper. Rain fell generally in the Punjab on the 3rd and again in larger amounts on the 6th and 7th. The North-Western Provinces obtained light showers on the 3rd and 4th, giving an average of three-tenths of an inch, and fairly general rain on the 7th and 8th. The western and eastern districts received amounts averaging approximately an inch, and the central districts amounts averaging about half an inch. Bihar, Bengal, Orissa, Chota Nagpur and Assam had showers on the 4th and again on the 7th and 8th. The largest fall on the 7th was 1·4 inches at Hazaribagh, and on the 8th 2·09 inches at Jafferband in Cachar.

(V) *Disturbance of the 20th to the 23rd February 1877.*—This depression appeared on the North-West frontier on the 19th and advanced across India. It gave rise to a shallowish secondary depression in the Punjab on the 20th, which filled up rapidly during the next 24 hours. The Punjab received showers on the 20th and general moderate rain on the 21st. The rainfall was heaviest in the northern districts. The North-Western Provinces obtained local showers on the same day. The rainfall extended to Bihar on the 22nd. Little or no rain fell in Bengal during this disturbance.

The following comparative statement of the rainfall of January and February 1877 on Northern India, extracted from Mr. Blanford's monograph on "The Rainfall of India," shows fully the excessive character of the rainfall of the cold weather season of 1876-77, more especially in Upper India:—

PROVINCE.	Number of Stations.	JANUARY 1877.		FEBRUARY 1877.		TOTAL OF PERIOD.	
		Actual mean.	Variation.	Actual mean.	Variation.	Actual mean.	Variation.
Western Himalaya	26	Inches. 5'1	Inches. +2'8	Inches. 4'4	Inches. +1'1	Inches. 9'5	Inches. +3'9
Punjab Plains	29	2'5	+1'5	3'0	+2'0	5'5	+3'5
North-Western Provinces and Oudh	45	2'2	+1'4	1'5	+0'9	3'7	+2'3
Rajputana (East Division)	18	0'3	+0'1	0'6	+0'3	0'9	+0'4
„ (West) „	1	<i>Nil</i>	—0'3	1'1	+0'8	1'1	+0'5
Central India States	21	1'5	+1'1	0'9	+0'5	2'4	+1'6
Bihar	14	2'1	+1'5	1'5	+0'9	3'6	+2'4
Western Bengal	10	2'0	+1'5	2'3	+1'4	4'3	+2'9
Lower Bengal	28	1'7	+1'3	1'7	+0'7	3'4	+2'0
Eastern Himalaya	7	1'4	+0'7	0'5	—0'3	1'9	+0'4
Assam and Eastern Bengal	17	1'3	+0'6	1'5	+0'2	2'8	+0'8
Orissa and Northern Circars	16	1'2	+0'9	2'6	+2'0	3'8	+2'9
Central Provinces, South	19	2'9	+2'4	0'9	+0'5	3'8	+2'9
Berar and Khandesh	13	1'4	+1'0	0'5	+0'4	1'9	+1'4

1877-78.

Abnormal features of the meteorology of India in 1877.—The cold weather of 1876-77 was remarkable for the number of storms and for the heavy precipitation which accompanied them in Northern India and the adjacent mountain districts. The snowfall was especially excessive in the Garhwal and Kumaun Himalayas. The hot weather was cooler than usual, more especially in Upper India. The abnormal features in the distribution of pressure were unusually steadily marked. Pressure was on the average of the whole of India steadily and largely above the normal. Pressure was locally in defect in Northern India, and a ridge of relatively high pressure stretched across the head of the Peninsula. The rains were later than usual. A feeble burst occurred in Bengal during the first ten days of June followed by a prolonged break, but the monsoon was not fully established until nearly the end of the month. On the West Coast it did not

advance beyond Malabar until the third week of the month. The rains were established on the 18th June at Bombay and on the 24th in the Central Provinces. The distribution of rainfall was much more irregular than usual. Burma and Malabar received excessive rain in June, but with these exceptions the rainfall was generally in defect. The Bombay current was very weak in July and August, and the Bengal current was chiefly directed to Burma and North-Eastern India. The rainfall of these two months was in general defect, except in North-East India and Burma.

The Bay current withdrew earlier than usual from the Gangetic plain, and the rainfall of September was very scanty in the Punjab and the North-Western Provinces. Bengal and Burma on the other hand received copious rain. The chief feature of the month was the unusual strength of the Bombay current and its determination to the Peninsula. Heavy rain fell in the Deccan, Mysore and Madras, which terminated the drought of 1876-77. Madras and Mysore continued to receive unusually abundant rain in November and December from the retreating south-west monsoon.

Upper India obtained abnormal rain during the same period, chiefly from disturbances of the cold weather type. These were very feeble in November, but were of considerable intensity in December. The chief feature of these disturbances was the heavy rainfall which accompanied depressions of very slight intensity in Upper India.

The following table gives the variations from the normal of the rainfall of the south-west monsoon of 1877, and shows the general character of the distribution of that rainfall:—

Division.	Variation from normal of	
	Ordinary South-west monsoon rainfall June to September, 1877.	Retreating south-west monsoon rainfall October to December 1877.
	Inches.	Inches.
Punjab Plains	— 8'20	+5'70
North-Western Provinces and Oudh	—21'60	+4'70
East Rajputana	—18'10	+3'50
Central India	—17'90	+2'80
Bihar	—15'00	+1'10
Lower Bengal	+ 3'90	—2'10
Assam	— 3'80	—2'60
Central Provinces	— 7'50	+2'10
Berar	—10'60	+1'40
Bombay	— 7'60	+1'90
Konkan, Malabar and Ghâts	—27'00	+7'80
Hyderabad	— 9'20	+3'30
Mysore and Bellary	— 1'20	+3'60
Burma	+14'00	—0'80

Pressure in October and November 1877 was considerably in excess in the Indian area, as it had been from during the previous twelve months. It was locally in excess

in these months in the south-east of the Bay and Burma, and considerably in defect in Upper India relatively to the general condition. The most important feature in the pressure distribution was a persistent slight deficiency at the higher level stations. The following table shows the large excess of pressure in the Indian area during the cold weather period of 1877-78:—

MONTH.		Variation of mean pressure of the Indian land area from the normal.
September 1877		+ '049
October "		+ '055
November "		+ '032
December "		— '004
January 1878		+ '028
February "		+ '034
March "		+ '043

The following summary of the chief features of the cold weather of 1877-78 is taken from Mr. Blanford's monograph on "the Rainfall of India":—

"The rainfall of January 1878 was above the average in the North-Western Provinces and Bihar, Northern Rajputana, the Eastern Punjab and the North-West Himalayas. This was mainly due to the formation of a barometric depression in the Deccan, Khandesh and Berar, to the north-east of which the fall was heavy. At the beginning of the month there was rain in Bengal, the result of a travelling depression, which had appeared in the Punjab at the end of December, and moved gradually eastwards. And near the end of the month another similar depression made its appearance in the extreme north of the same province, and travelled eastwards, like its predecessor. Heavy rain also occurred in the southern half of the Carnatic, but there was no other rain in the Peninsula.

"February was very rainy in Baluchistan and the Punjab, especially on the hills; but there was less than the average over most other parts of Northern India, excepting Assam and Cachar; and, excepting in the Central Provinces south of the Satpuras, scarcely any fell in any part of the Peninsula.

"March was a dry month, with a high temperature. In the Punjab and North-Western Provinces, except on and near the hills, there was scarcely any rain, and, excepting in the Northern Circars and the southern portion of the Western Ghâts, the Peninsula was almost equally rainless. It was the same in Burma. In April, however, there was much more than the usual amount of rain on the North-West Himalayas, the Punjab and the North-Western Provinces and Oudh, and also very generally in Bihar and Bengal, but not in Orissa. In the Central Provinces and Berar there was a good average; and there was very general rain in the Deccan, which is hardly usual in this month. In many parts of Madras too, including the Northern Carnatic, Bellary and Mysore, there was rather more than usual. But in Burma and at the Bay Islands there was either no rain or less than the usual amount.

"May was equally rainy, or even more so. In nearly all parts of the Punjab, and especially on the Himalayas, the average was largely exceeded; in many places more than doubled; and there was more or less excess all over the Gangetic plain, Rajputana, Central India, the Central Provinces and Western Bengal; also to some extent in Guzerat. In most other parts of Bombay there was

either no rain or less than the usual amount; and in Madras, though there was more than usual in the Godavery districts, those south of the Cavery and in South Canara and Malabar there was rather less in most other parts of the Presidency.

"On the whole, notwithstanding the dryness of March, the precipitation of the cold weather and spring, from the beginning of November to the end of May, on the North-Western Himalayas, was the heaviest on record, exceeding even that of the previous season, and averaging double the normal amount. It was as excessive at Bannu, Kohat and Peshawar as in Kumaun and Garhwal, but not apparently so far east as Katmandu, at which station the fall was less than the average."

Storms of the cold weather period of 1877-78.—An unusually large number of storms occurred during this period, of which the following gives accounts of the more important :—

(I) Disturbance of the 23rd to the 28th November 1877.—This was due to a shallow depression crossing Northern India, which gave rise to a small secondary depression in the North Punjab. It gave very heavy rain to the North Punjab, and showers of little importance in the remainder of the Punjab and the North-Western Provinces. The following are the more remarkable rainfalls due to the storm :—

STATION.	DATE.	Amount in inches.
Kohat	23rd	4'00
	24th	3'30
	25th	2'40
Peshawar	24th	2'80
	25th	2'70

(II) Storm of the 9th to the 12th December 1877.—This depression apparently advanced from Baluchistan into Sind on the 8th and advanced rapidly across Northern India. The chief feature of the storm was a deep secondary depression which formed in the North-East Punjab on the 9th. It filled up with unusual rapidity on the afternoon and evening of the 10th. For example, pressure increased four-tenths of an inch during the 24 hours ending at 10 P.M. of the 10th at Lahore. The Punjab received heavy and general rain on the 9th and 10th. The North-Western Provinces obtained rain on the same days, but the rainfall was light and local on the 10th. The rainfall extended to Bengal on the 10th and 11th, but was very light. The following gives the more remarkable falls in the Punjab :—

STATION.	DATE.	Amount in inches.
Sirsa	9th	2'60
Ludhiana	9th	2'40
Jullundur	9th	2'50
Dharmasala	9th	2'40
Sialkot	9th	2'00

STATION.	Date.	Amount in inches.
Gurdaspur	9th	4'60
Gujranwala	9th	3'20
Jhelum	9th	3'00
Guzerat	9th	4'20
Abbottabad	9th	2'80
Rohtak	10th	2'20
Umballa	10th	2'20
Ludhiana	10th	2'30
Jullundur	10th	2'40
Hoshiarpur	10th	3'00
Dharmasala	10th	2'40

In the North-Western Provinces the total rainfall due to the storm diminished from an average of 2·5 inches in the western districts to a quarter of an inch in the eastern districts.

(III) Disturbance of the 27th to 31st December 1877.—This disturbance appeared on the North-West frontier on the 27th and 28th and advanced eastwards across Northern India during the next three days. It did not give rise to a secondary depression in the Punjab. The Punjab received fairly general rain from the 27th to the 29th. The following gives the more noteworthy rainfalls :—

DISTRICT.	Station.	Date.	Amount in inches.
HAZARA	Abbottabad	27th	2'90
SIALKOT	Sialkot	28th	2'10
GURDASPUR	Gurdaspur	28th	2'40
RAWALPINDI	Rawalpindi	28th	2'00

The North-Western Provinces obtained light showers on the 29th and 30th, Bihar on the 30th, and Bengal and Assam on the 31st.

The disturbance hence travelled across Northern India in about four days, or at the normal rate of progression of these cold weather storms.

(IV). Disturbance of the 9th to the 13th January 1878.—This was apparently a small and irregular diffused disturbance of the class more common in the hot weather than in the cold weather season. When a storm of this class occurs in a wetter cold weather season than usual, it is generally attended by moderate rain, and the present case was an example in point. The following gives an account of the disturbance extracted from Mr. Blanford's Report on the Meteorology of the year :—

"From the 2nd, when the rain due to the previous storm ceased in Lower Bengal, to the 8th or 9th, the atmospheric pressure rose in Northern India generally and Bengal, and over the Bay and the east-

ern half of the Peninsula, while it remained stationary in the west. Thus the latter region became the seat of minimum pressure, and south-east winds prevailed over the central part of the Peninsula, while winds became easterly on the east coast and southerly in the southern part of the Central Provinces. The seat of highest pressure was in Sind and the Thar desert, and on the 8th pressure reached its maximum, *viz.*, 30.35" at sea-level. In Guzerat, between the seats of maximum and minimum pressure, the winds were northerly. A fall then set in all over Western India, while a further rise took place in Bengal. The winds became more southerly in the Deccan and the Godavery basin, while in the Southern Carnatic they were north-east, as they had been throughout. Easterly winds set in up the Gangetic valley, with a rise of 3° or 4° of temperature; and, on the 10th, slight rain fell in the North-Western Provinces and Bundelkhand. This was followed by a rise of pressure on the 11th; but on the 12th pressure fell again locally in the Eastern Punjab, and on the 13th all over North-Western India, including Rajputana and Central India, and the upper part of the North-Western Provinces. This fall was followed by more copious rain on the 12th and 13th, chiefly in the same region; and then the pressure rose again from the westward, bringing dry westerly or northerly winds and fine weather."

(V) *Storm of the 23rd to the 28th January 1878.*—This storm consisted of a primary depression which formed or appeared in Sind and West Rajputana on the 24th and drifted across Northern India during the next four days, and of a deep secondary depression which formed in the North Punjab during the 24 hours preceding 10 A.M. of the 26th and filled up equally rapidly during the next 24 hours. The following gives the changes of pressure at stations in Northern India during the storm:—

STATION.	PRESSURE CHANGES IN 24 HOURS PRECEDING 10 A.M. OF			
	25th.	26th.	27th.	28th.
Jacobabad	—'037	—'113	+ '030	+ '266
Peshawar	—'118	—'331	+ '106	+ '309
Lahore	—'085	—'222	—'009	+ '281
Roorkee	—'033	—'120	—'113	+ '170
Allahabad	—'030	—'080	—'092	+ '107
Bankipore	—'011	—'067	—'059	+ '030
Calcutta	—'007	—'064	—'040	—'034

These figures show clearly that the disturbance was a double one, consisting of a shallowish primary depression, and of a deep secondary and almost stationary depression in the Punjab.

The following account of the storm is taken from Mr. Blanford's Report on the meteorology of India for the year 1878:—

"The second fall of rain in January 1878 in Upper India was brought about in the following manner. Up to the 22nd of the month an area of maximum pressure maintained its position in Sind and the Thar desert, as noticed above; and, in general, the pressure of this tract was higher than that of any other part of India; although, during the oscillations of pressure which seem to have affected Western India more than Bengal, on several days the maximum pressure at Hyderabad fell to an equality with that of Bihar, and occasionally of the higher portions of the Gangetic plain. On the 22nd or 23rd the pressure fell more rapidly in Sind, Guzerat and Western Rajputana than elsewhere; and, on the 25th, a local minimum was developed at Deesa. Between 10 A.M. of the 25th and 10 A.M. of the 26th the barometer fell from 0.2" to 0.4" in the Upper Punjab

During this fall of pressure in Western India the winds had become very unsteady and variable throughout Northern India, while in the Peninsula they continued to be more or less southerly and easterly. In the Punjab they became southerly on the 23rd; and, on the 24th, a current appears to have been established in the Eastern Punjab from the south-east, while, in the upper part of the province, there was a tendency to a cyclonic movement. At the same time light rain began to fall at Rawalpindi and on the hills, but it was not till the evening of the 25th that it became general in the upper provinces, simultaneously, it would seem, with the sudden fall of the barometer in the Punjab and the establishment of southerly or easterly winds all over Northern India. This rain was distributed over the Punjab, North-Western Provinces and Bihar, and on the 27th and 28th extended to Western Bengal. It lasted three days; but, between the 27th and 28th, the pressure rose in the whole of the Indus region as rapidly as it had fallen; and, as on the previous occasion, from the seat of maximum pressure re-established in Sind and Western Rajputana, dry westerly winds blew down the upper provinces."

This account of the storm indicates that a shallow (primary) disturbance was propagated eastwards from the North-West frontier to Bengal during the period, the 24th to the 28th of January, and that a deep secondary depression formed in the North Punjab during the 24 hours preceding 10 A.M. of the 25th. This depression filled up on the 27th as rapidly as it formed.

(VI) Disturbance of the 9th to the 12th February 1878.—This depression appeared on the North-West frontier on the morning of the 9th and was transmitted rapidly eastwards across Northern India during the next two days and passed through Bengal on the 12th. The barometric fall in the central depression decreased from two-tenths of an inch on the North-West frontier to one-tenth in Bengal. There was a slight tendency to the development of a secondary depression on the 11th in the Punjab, but it did not proceed beyond the initial stage. Showers more or less local in character were received in Northern India. Heavy snow appears to have fallen in the Kashmir Himalayas during this storm.

(VII) Storm of the 24th to the 28th February 1878.—The storm consisted of a primary depression which appeared in the North-West frontier on the 23rd and 24th and marched across Northern India during the next three days, and of a deep secondary depression in the North Punjab. The following table, giving the barometric changes day by day at representative stations in Northern India from the 24th to the 28th shows fully the double character of the storm:—

STATION.	PRESSURE CHANGES IN 24 HOURS PRECEDING 10 A.M. OF				
	24th.	25th.	26th.	27th.	28th.
Murree	—'018	—'039	P	P	+ '194
Simla	P	P	—'174	—'096	+ '138
Jacobabad	—'111	—'072	—'017	+ '028	+ '157
Peshawar	—'109	—'103	—'256	+ '181	+ '223
Lahore	—'042	+ '007	—'260	+ '101	+ '212
Roorkee	—'035	+ '033	—'151	+ '038	+ '124
Allahabad	—'012	—'012	—'122	+ '043	+ '136
Bankipore	—'004	+ '028	—'119	+ '023	+ '129
Calcutta	+ '046	+ '010	—'076	—'056	+ '117

The precipitation during this storm occurred chiefly in the Western Himalayan districts and the Punjab. Little or no rain fell in the North-Western Provinces. The primary depression was very slight, and advanced even more rapidly than usual across Northern India in about 80 hours.

The preceding account has shown that an unusually large number of storms appeared in Northern India during the period under discussion, and that three at least were accompanied by deep and well-defined secondary depressions in the Punjab. In consequence the rainfall of the cold weather of 1877-78 in Upper India was abnormally abundant. The following gives data for a few typical stations:—

STATION.	December 1877.	January 1878.	February 1878.	Total of period.	Normal of period.	Variation of actual from normal.
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.
Peshawar	3'07	1'99	2'77	8'43	3'44	+4'99
Rawal Pindi	6'86	0'97	4'71	12'54	5'53	+7'01
Sialkot	4'74	1'12	2'92	8'78	4'03	+4'75
Lahore	2'57	0'20	2'46	5'23	2'29	+2'94
Roorkee	3'20	2'40	1'30	6'90	3'86	+3'04
Murree	5'37	1'12	9'12	15'61	7'40	+8'21
Simla	6'10	2'23	6'13	14'46	6'61	+7'85
Agra	2'45	Nil	Nil	2'45	1'05	+1'40
Allahabad	0'30	2'50	Nil	2'80	1'40	+1'40
Patna	0'72	1'11	0'13	1'96	1'30	+0'66
Calcutta	2'19	Nil	0'23	2'42	1'72	+0'70

The snowfall in the Afghan mountain districts and the Western Himalayas was largely above the average. It appears to have been most excessive in the Kashmir Himalayas. The following graphic account of the snowfall in that area is taken from a paper by N. Lyddeker, Esq., Geological Survey of India:—

“Among the inhabitants of the Kashmir Himalayas the winter and spring of 1877-78 will long be memorable on account of the enormous quantity of snow which then fell on their mountains and valleys, and still more on account of the grievous famine which followed this excessive snowfall. So excessive indeed was this snowfall that no tradition or record exists, even amongst the oldest inhabitants, of anything approaching to such a fall. I have therefore thought that a short account of this abnormal snowfall, and of the destruction inflicted by it on the indigenous animal life, might be thought not unworthy of a place in the records of the Asiatic Society, and have accordingly put together the following notes:—

“Early in the month of October 1877 snow commenced to fall in the valley and mountains of Kashmir, and from that time up to May 1878 there seems to have been an almost incessant snowfall on the higher mountains and valleys; the inhabitants have indeed informed me that in places it frequently snowed without intermission for upwards of ten days at a time. It is extremely difficult to obtain from the natives any correct estimate as to the amount of snow which fell in any place; but at Dras, which has an elevation of about 10,000 feet, I estimated the snowfall from the native account as having been from 30 to 40 feet thick on the level.

“The effects of this enormous snowfall are to be seen throughout the country. At Dras the well built travellers' bungalow, which had stood, I believe, some thirty years, was entirely crushed down by the weight of the snow which fell on it. In almost every village in the neighbouring moun-

tains more or less of the log-houses have likewise fallen; while at Gulmarg and Sonamarg, where no attempt was made to remove the snow, almost all the huts of the European visitors have been utterly broken down by the snow.

"In the higher mountains whole hill-sides have been denuded of vegetation and soil by the enormous avalanches which have swept down them, leaving vast gaps in the primæval forest, and choking the valleys below with the debris of rocks and trees.

"As an instance of the amount of snow which must have fallen on the higher levels, we will take the Zogi pass, leading from Kashmir to Dras, which has an elevation of 11,300 feet. I crossed this pass early in August last, and then found that the whole of the ravine leading up to the pass from the Kashmir side was still-filled with snow, which I estimated in places to be at least 150 feet thick. The road at that time was carried over the snow up the middle of the ravine, the true road which runs along one bank of the ravine being still entirely concealed by snow. It seems to me quite impossible that even half the amount of snow then remaining could be melted during the summer.

"I heard subsequently from a traveller who crossed the pass on the 5th of September that the road was then just beginning to get clear from snow, and that some of his loads were carried along it while others were taken over the snow in the ravine.

"In ordinary seasons this road on the Zogi pass is clear from snow, some time during the month of June; if we refer to page 223 of Mr. Drew's "Jummoo and Kashmir Territories," we shall find that in speaking of this pass he says: 'About the beginning of June the snow-bed breaks up, and the ravine is no longer passable.'

"It is thus apparent that the road across the Zogi-la was not clear of snow during the past summer until three months later than it is in normal seasons, while the ravine early in September was still filled with snow. I crossed the same pass in August 1874, and at that time there was not the slightest trace of snow to be seen anywhere on the pass, or in the ravine leading up to it. As another instance of the great snowfall, I will take the valley leading from the town of Dras up to the pass separating that place from the valley of the Kishenganga river. About the middle of August almost the whole of the first-mentioned valley, at an elevation of 12,000 feet, was completely choked with snow, which in places was at least 200 feet in thickness. In the same district all passes over 13,000 feet were still deep in snow at the same season of the year. In ordinary seasons the passes in this district, which are not more than 15,000 feet in height, are completely cleared of snow at the beginning of August, except in a few sheltered ravines. During last summer, however, it was quite impossible that the snow could have even melted on the passes.

"Traces of this great snowfall were even to be observed in the outer hills in September, since at the end of that month I saw a patch of snow resting in a hollow of the Haji Pir ridge above Uri, which is only a little over 9,000 feet in height. The Thakadar of this place told me that he had never before seen snow there after the beginning of June.

"It is almost unnecessary to point out that if a snowfall similar to the above were to be of constant occurrence in the Himalaya, the permanent snow-line would lie at a much lower level than it does at present, and that the glaciers would greatly increase in size, and descend much lower into the valleys.

"In conclusion, it remains to notice the destruction of animal life caused by this unusual snowfall. In the Upper Wardwan valley I was told by some European travellers that they had several times seen numbers of Ibex embedded in the snow; in one place upwards of sixty heads were counted, and in another the number of carcasses was estimated by my informant as little short of one hundred. I myself twice saw some fifteen carcasses of small Ibex embedded in the snow-drifts of the Tilail valley.

"The most convincing proof, however, of the havoc caused among the wild animals by the great snowfall is the fact that scarcely any Ibex were seen during last summer in those portions of the Wardwan and Tilail valleys, which are ordinarily considered as sure finds. Near saline springs, in the latter valley, Ibex are always to be found in the later summer, but this year I only heard of one solitary buck, probably the sole survivor of a herd, having been seen at these salt-licks. The native shikaris say that almost all the Ibex have either been killed by the snow, or have migrated into Skardo, where the snowfall was less.

"The Red bear (*Ursus isabellinus*) was also far less numerous during the past summer than in ordinary seasons, and the shikaris say that numbers of them have perished owing to their winter quarters having been snowed up so long that the occupants perished from hunger."

1878-79

Chief abnormal features of the meteorology of India in 1878.—This year was the last of a period of nearly three years of excessive pressure and of diminished and very irregularly distributed rainfall. It included the Madras famine of 1876-77 and a severe drought in Upper India in 1877-78. During the first five months of the year the mean pressure of the Indian area was in excess. Relatively to this general state pressure was in defect in the peninsula and in excess in Northern India. The local excess was throughout the whole period greatest in North-Eastern India, and the deficiency in the peninsula was greatest in Malabar and the Konkan. The cold weather and hot weather rainfall in Upper India was very considerably in excess, and an unusually large proportion of it fell in April and May. Excessive and untimely snow was received during the whole period in the Western Himalayas, and more especially in Kashmir. The chief features of the pressure anomalies in April and May were—

- (1) A considerable excess of pressure in North and North-Eastern India, which was most marked in Bengal and Bihar. The positive anomalies in May were absolutely greatest at Berhampore (+0.48"), Calcutta (+0.36") and Burdwan (+0.31").
- (2) Pressure was locally in defect in North-Western India and the greater part of the Peninsula. The negative anomalies in May exceeded .035" in Kanara and Malabar.

The monsoon rains were very late in setting in, and June was a very dry month. They were abundant in July, August and September, and every part of India received rainfall in excess of the normal, except Bihar, the North-Western Provinces and Central India, in which there was a moderate deficiency, and Burma in which there was a deficiency ranging from 10 to 20 per cent. in amount. The rainfall was especially abundant in Guzerat, the Konkan, Mysore, the Deccan and Berar. A noteworthy feature of the south-west monsoon was the excessive rain in the areas which usually receive their rainfall from the Bombay current and the very deficient rainfall in Burma.

The local pressure anomalies in July and August were similar in character to those which had obtained during the first six months of the year, and were even more strongly marked than in April and May. The most noteworthy features were—

- 1st.—Increased pressure in Northern India, greatest in amount in East Bengal and Assam, where the positive anomalies of the months of July and August averaged .05."
- 2nd.—Decreased pressure in the Peninsula, greatest in amount in the West Coast districts, in which it averaged .05" in August.

The mean monthly pressure of the whole Indian area had been more or less considerably in excess during the previous two years, but in September it fell considerably below the normal, and pressure was more or less in defect during the next twelve months.

The anomalies in September were the same in kind but less in amount than in May and the chief features in the pressure conditions accompanying the retreat of the south-west monsoon were a considerable excess of pressure in the south-east of the Bay and the Andaman Sea, and a deficiency of pressure in the west and north-west of the Bay. The

latter feature was perhaps the continuation of the low pressure in Western India during the south-west monsoon proper.

The rainfall of September was practically normal in amount. The monsoon currents withdrew from Upper India in the fourth week of September. The chief features of the pressure distribution in the months of the retreating south-west monsoon period of 1878 were as follows :—

- (1) General deficiency of pressure over the whole Indian area averaging—'057" in November and —'049" in December.
- (2) Moderate local excess of pressure in North-Western India.
- (3) General deficiency in the Bay and North-Eastern India, which was most marked in the north-west of the Bay in November and December and in Arakan in January.

The following gives a brief summary of the variations of the south-west monsoon rainfall of 1878 from the normal throughout India :—

DISTRICT.	VARIATION FROM NORMAL OF	
	Ordinary south-west monsoon rainfall, June to September 1878.	Retreating south-west monsoon rainfall, October to December 1878.
	Inches.	Inches.
Punjab	+ 1'27	— 1'10
Rajputana	+ 1'78	— 0'95
Central India	— 3'35	— 0'67
North-Western Provinces	— 3'99	— 1'52
Bengal	+ 1'92	+ 0'04
Assam	+ 12'75	+ 0'17
Central Provinces	+ 1'85	+ 0'03
Berar	+ 12'77	+ 2'97
Hyderabad	+ 12'21	+ 1'29
Bombay	+ 19'63	+ 2'30
Madras	+ 9'48	+ 1'59
Mysore and Coorg	— 0'39	— 1'49
Burma	— 27'66	+ 5'51

The following gives the chief meteorological features, which were probably more or less influential in determining the character of the cold weather rainfall of 1878-79 in India :—

- 1st.—The south-west monsoon currents in 1878 were more vigorous than usual, and were later in retreating from North-Western India than usual.
- 2nd.—The south-west monsoon rainfall was most excessive in Western India, and was deficient only in the North-Western Provinces, Bihar and some parts of Central India.
- 3rd.—The retreating south-west monsoon rains were slightly more abundant than usual, more especially in Burma.
- 4th.—There was a general and large deficiency of pressure in the Indian area

during the whole period from September 1878 to March 1879. The following gives data :—

MONTH.	Variation of mean pressure of the Indian land area from the normal.
September 1878	—'034
October "	—'056
November "	—'057
December "	—'049
January 1879	—'007
February "	—'026
March "	—'009

5th.—The deficiency was much less marked at the hill stations than at the plain stations, or there was a relative excess of pressure at the hill stations as compared with the neighbouring plain stations. The following gives data for four pairs of stations :—

MONTH.	VERTICAL PRESSURE ANOMALY.			
	Leh minus Lahore.	Murree minus Peshawar.	Chakrata minus Roorkee.	Ranikhet minus Bareilly.
September 1878	+ '007	+ '021	+ '001	— '014
October "	+ '054	+ '043	+ '032	+ '032
November "	+ '083	+ '013	+ '029	— '015
December "	+ '051	0	+ '013	— '002
January 1879	+ '048	+ '032	+ '001	+ '012
February "	+ '038	+ '043	+ '019	+ '014
March "	— '047	+ '004	— '021	— '007

The mean excess at the hill stations relative to the neighbouring plain stations for the period was '033".

The cold weather of 1878-79 was remarkable for its scanty rainfall and absence of cold weather storms. The following table gives the average actual and normal rainfall from 1st December 1878 to 1st April 1879 in Northern India :—

DISTRICT.	Average actual rainfall of 1st December to 1st April.	Normal rainfall of period.	Variation.
Punjab	Inches, 2'00	Inches, 4'22	Inches, —2'16
Sind	0'35	0'94	—0'59
Rajputana	1'10	0'86	+0'24
Central India	0'44	1'24	—0'80
Central Provinces and Berar	0'42	1'53	—1'11
North-Western Provinces and Oudh	0'65	2'22	—1'57
Bengal	1'31	2'75	—1'44
Assam	2'38	6'24	—3'86

Storms of the cold weather of 1878-79.—Not a single storm occurred during the whole cold weather period of 1878-79 with the exception of two small disturbances, which barely come within the category of cold weather storms as defined in the introduction. These were—

1st.—Depression of 19th to 22nd February.

2nd.—Depression of 10th to 15th March.

The following gives a brief account of these two disturbances:—

(I) Disturbance of 19th to 22nd February 1879.—The first indications of the disturbance were shown in Central India and Rajputana on the 18th. The barometer was falling over the whole of North-Western and Central India, but the fall was slightly larger in Rajputana than elsewhere, and the skies were clouding over, and some showers were received.

19th February.—The barometer continued to fall, but the changes were generally small, though somewhat irregular. Very strong north-east winds were blowing in North-Western India, more especially at Kurrachee and Deesa.

There was no barometric depression in Rajputana or Central India, and the only barometric indications of disturbance were the irregular pressure changes. Duststorms and thunderstorms had occurred during the previous afternoon in Sind, Rajputana, the western states of Central India, Guzerat and Khandesh.

20th February.—The barometer had again fallen generally, the changes varying from one to two tenths of an inch in Northern India, and pressure was very uniform over the whole of Northern and Central India. The changes were marked by much local irregularity. Temperature had decreased rapidly in the area over which rain had fallen on the preceding day. Winds were very light in Northern India except in Bengal, where north to north-west winds prevailed. There was hence no low pressure area, and the winds in Rajputana and Central India were exceedingly irregular, and indicated a period of stagnation with very light local winds. Thundershowers had fallen at nearly all the rainfall-reporting stations in Rajputana, Central India and the northern districts of the Central Provinces. Skies were clouded over the greater part of Upper and Central India, and more especially in the Punjab, the North-Western Provinces, Rajputana, North Bombay, Central India, Berar and the Central Provinces.

21st February.—The barometric movements of the previous 24 hours were very small and somewhat irregular. The only noteworthy feature in the pressure distribution was its uniformity over nearly the whole of India. The following examples illustrate this feature:—

STATION.	Pressure at 10 A.M. reduced to sea- level and gravity.	STATION.	Pressure at 10 A.M. reduced to sea- level and gravity.
Mooltan	29.926	Sialkot	29.923
Jubbulpore	'897	Purnea	'914
Surat	'908	Burdwan	'906
Nagpur	'903	Lucknow	'912
Sholapur	'894	Saugor Island	'912
Madras	'900	Port Blair	'882

Winds were very light and irregular, and in many cases blew from nearly opposite directions at neighbouring stations, *e.g.*—

Station.	Wind direction.	Station.	Wind direction.
{ Calcutta,	ENE.	{ Benares,	SW.
{ Saugor Island,	NW.	{ Allahabad,	ESE.
{ Seoni,	SW.	{ Indore,	SSW,
{ Nagpur,	E.	{ Khandwa,	N.

Skies had almost completely cleared, and a rapid decrease of humidity had occurred in Central India and Rajputana. Some local thundershowers of little importance had fallen during the previous 24 hours in the Punjab and the western districts of the North-Western Provinces.

The disturbance disappeared completely before the evening of the 22nd.

It was hence a diffused disturbance which originated in India and was due to local actions and conditions. It in fact rather resembled the disturbances of the hot weather than of the cold weather. There was throughout the disturbance no low pressure area or cyclonic circulation. It gave a series of thunderstorms and moderate general rain to Rajputana and Central India. The following is a statement of the rainfall due to the storm:—

DISTRICT.	AVERAGE ACTUAL RAINFALL OF			TOTAL OF PERIOD.
	19th.	20th.	21st.	
	Inch.	Inch.	Inch.	Inch.
Rajputana	0'33	0'50	0'03	0'86
Central India	0'18	0'14	0'05	0'37
Central Provinces	0'01	0'13	0'05	0'19
Punjab	Nil.	Nil.	0 04	0'04
North-Western Provinces	Nil.	002	0 05	0'07

(II) *Disturbance of 10th to 14th March 1879.*—This storm gave moderate rainfall to the Punjab and local showers in Rajputana and the western districts of the North-Western Provinces. Its track is given in chart 1, plate LVI.

The barometric changes of the 8th and 9th were somewhat irregular but generally small in amount. Westerly winds prevailed in the Gangetic plain and Bengal, southerly winds obtained on the Sind coast, and north-west winds on the Bombay coast. Skies were clear over nearly the whole of Northern and Central India, but were overcast on the North-West frontier and Baluchistan on the 9th.

The barometer fell rapidly in North-Western India during the day, and on the morning of the 10th a small depression had appeared in Baluchistan and was approaching Upper Sind. The following observations show its position approximately:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M., reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Quetta		—'185	—'127	SW.	14	3
Kurrachee	29'962	—'064	+ '004	S.	9	8
Jacobabad	29'887	—'224	—'044	ESE	?	9
Mooltan	29'944	—'133	—'020	N.	2	10

Skies were now overcast in the Punjab and Sind but were clear in other districts. The air was somewhat damper than usual. Winds were unchanged in Northern India and the Bombay coast districts. Light showers had fallen in Sind on the 8th and 9th, but on the 10th the rainfall was confined to the north and west of the Punjab.

11th March.—The barometer now began to fall rapidly in the North Punjab, and a secondary depression formed in that area during the day. The primary depression had advanced during the preceding 24 hours from Baluchistan into Upper Sind. The following observations define its position:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Quetta	"	+035	—092	Calm.	7	4
Kurrachee	29'940	—022	—015	WNW	13	4
Hyderabad	29'896	?	—055	W	?	7
Jacobabad	29'855	—032	—069	Calm.	?	9
Mooltan	29'873	—071	—079	NNE	4	6

The position of the secondary depression forming in the north of the Punjab is shown by the following observations:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Murree	"	—081	—189	SE	...	0
Peshawar	29'853	—152	—107	NW	4	0.
Lahore	820	—121	—110	W	4	10
Sialkot	839	—149	—102	SSE	3	8

There was thus a fairly-well defined cyclonic circulation in the secondary depression, although the winds were by no means strong.

Skies were overcast in Rajputana, the East and North Punjab and the hill districts, and were clearing in Sind and the West Punjab.

A large increase of temperature had occurred during the preceding 24 hours in Rajputana and Central India, greatest at Delhi (+7°8') and Bickaneer (+7°3'). Local showers had fallen in the Punjab and moderately heavy rain or snow in the hill districts.

12th March.—The barometric changes of the previous 24 hours were very irregular, and in the majority of cases small in amount. So far as can be judged from the observations, the primary depression had disappeared and the secondary depression had not developed to any extent. The following observations define its position:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Murree	"	+056	—129	SSW	?	8
Lahore	29'818	—002	—094	NW	3	3
Sialkot	830	—009	—102	NW	2	0
Peshawar	877	+024	—064	W	4	7

Skies were less clouded in the Punjab and the air was generally drier. Westerly winds prevailed in Bihar and the North-Western Provinces, and south-westerly winds in South Bengal. A few local showers had fallen in the Punjab and Rajputana. Moderately heavy rain had been received in the Punjab and the North-Western Provinces hill districts. Dharmasala reported 2·4 inches, Simla 1·15 inches and Chakrata 1·77 inches.

13th March.—A rapid fall of pressure occurred over the Punjab during the previous 24 hours and the secondary depression intensified considerably. The following data define its position:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A. M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Peshawar	29·745	—·132	—·198	W	6	10
Dera Ismail Khan	·781	—·108	—·178	W	2	0
Sialkot	·776	—·054	—·159	Calm	1	10
Lahore	·725	—·093	—·192	NE	3	10

Winds had strengthened to some extent in Upper India and skies clouded over again in the Punjab. Heavy and general rain had fallen during the previous 24 hours in the Punjab, and some light local showers in Rajputana and the western districts of the North-Western Provinces.

14th March.—The barometer had risen rapidly over the whole of North-Western India during the previous 24 hours, and partially filled up the secondary depression in the North Punjab. The Rawalpindi and Murree observations at this period were exceedingly doubtful. The following observations define its position:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Murree	?	?	?	SW	...	10
Peshawar	29·808	+·063	—·135	S	5	10
Sialkot	·848	+·072	—·080	ESE	3	5
Dera Ismail Khan	·833	+·052	—·119	Calm	1	3

Winds were light and irregular in Upper India. A very rapid reduction of temperature had occurred in the area of rainfall in the Punjab, greatest at Lahore (—11·8°) and Dera Ismail Khan (—8·5°). Light to moderate showers had fallen in the Punjab and western districts of the North-Western Provinces and heavy rain in the hills. Dharmasala, for example, had received 3·5 inches. Skies were however clearing.

15th March.—A further increase of pressure completely filled up the depression in the Punjab. Local showers were received in the Punjab and the western districts of the

North-Western Provinces, but the amounts were small. Skies cleared rapidly during the day, and on the morning of the 16th fine clear weather prevailed generally in Northern India.

1879-80.

Chief abnormal features of the meteorology of India in 1879.—The cold weather of 1878-79 was remarkably free from storms in Northern India, and the rainfall of the period was hence considerably below the normal. The mean pressure of India was steadily in defect from January to May.

March, April and May were unusually dry months over the whole of Northern and Central India, and temperature was hence more or less in excess throughout this period. The mean temperature of May in Northern India ranged from 2° to 6° above the normal, the excess being on the whole greatest in the North-Western Provinces.

There were no strongly marked persistent local anomalies of pressure in April or May.

The south-west monsoon set in on the Bengal coast about the 14th June. It commenced feebly on the Bombay coast about the 4th, and increased rapidly in strength on the 24th and subsequent days. Moderately strong monsoon currents then prevailed for a short time on the Bombay coast. The rainfall of June was generally quite up to the average. The distribution of the rainfall in July was very unusual. In Rajputana, Central India, the Central Provinces, Berar, Bombay and the Deccan, or in fact over the whole area usually dominated by the Arabian Sea monsoon current, the rainfall was very largely in defect. The greater part of the North-Western Provinces, Bihar, Bengal and Burma received normal or excessive rain.

The rainfall was largely in excess, more especially in North-Western and Western India and the Deccan, in the months of August and September. The monsoon currents withdrew from Upper India in the last week of September. The mean pressure of the whole of India, which had been approximately normal from June to August, was steadily in slight defect from September to the end of the year. Pressure in September was locally in moderate defect in the Bay and North-Eastern India and in excess in North-Western India. These anomalies continued throughout October, November and December, and were hence persistent.

The greater part of Madras received favourable rain during the retreating south-west monsoon period from October to December. A large portion of the rainfall accompanied cyclonic storms, and hence was very partially distributed.

On the whole, the monsoon rains of 1879 were abundant and favourable, notwithstanding that they were deficient in certain tracts, the chief of which were the Punjab, Central India, Western Bengal and a part of Lower Bengal.

The rains came to an end in the Punjab at the end of September, and in Rajputana, the North-Western Provinces, Central India, the Central Provinces, and Bihar in the first fortnight of October. A few days later, *viz.*, on the 19th, the heavy autumn rains set in on the Coromandel coast and in the Carnatic, and continued steadily till the end of the month, and were repeated later on, in November, when they accompanied some stormy weather.

The following gives a summary of the variations of the south-west monsoon rainfall throughout India:—

DISTRICT.	VARIATION FROM NORMAL OF	
	Ordinary south-west monsoon rainfall, June to September 1879.	Retreating south-west monsoon rainfall, October to December 1879.
	"	"
Punjab	— 1'69	— 0'69
North-Western Provinces and Oudh	+ 11'67	+ 1'35
Bihar and Bengal	+ 4'59	— 0'02
Assam	+ 11'38	— 0'69
Rajputana	+ 2'55	— 0'06
Central India	— 2'83	+ 1'05
Central Provinces	+ 4'13	+ 1'39
Berar	+ 1'17	+ 0'39
Bombay	+ 1'64	— 0'08
Madras	— 1'12	+ 0'28
Burma	— 2'23	+ 3'19

The following appear to be the chief antecedent meteorological features which determined the character of the cold weather rains of 1879-80 in Upper India—

1st.—The south-west monsoon currents of 1879 were on the whole above their average strength, and gave rainfall more or less above the average over the whole of India, with the exception of some parts of Bengal, Central India, and the Punjab, but the deficiency in these areas was small and of little importance.

2nd.—The retreating south-west monsoon rains were abundant and the south-west monsoon did not withdraw from the Bay until the end of December.

3rd.—The south-west monsoon currents retreated somewhat earlier than usual from Upper India, and the weather in October, November and December was somewhat drier than usual, temperature above the average, and winds very steady and contained abnormally strong northerly components.

4th.—Pressure was steadily below the normal in the Indian region, the deficiency in December being slightly greater at the hills than the plain stations in Northern India.

5th.—Pressure in November and December was in excess locally in North-Western India, and in defect in the peninsula and North-Eastern India. The negative anomalies slightly exceeded '02" in the east of the Bay and Burma. The local pressure anomalies were hence not large, although fairly persistent.

The pressure variations at the hill stations did not differ to any large extent from those at the neighbouring plain stations. Pressure was generally in slight defect at the hill stations relatively to the neighbouring plain stations, as is shown by the following data:—

MONTH.	PRESSURE DIFFERENCES, HILL <i>minus</i> PLAIN STATIONS.			
	Leh <i>minus</i> Lahore.	Murree <i>minus</i> Peshawar.	Chakrata <i>minus</i> Lucknow.	Ranikhet <i>minus</i> Bareilly.
	"	"	"	"
September 1879	—'023	—'024	—'023	—'017
October "	+ '014	0	—'005	—'002
November "	—'033	—'029	—'067?	—'037
December "	+ '016	—'023	—'023	—'015
January 1880	+ '073	+ '015	+ '033	+ '016
February "	—'019	—'038	—'003	—'011

Chief features of the meteorology of cold weather period 1879-80.—

The cold weather of 1879-80 was drier than usual over the whole of Northern India except Bengal. November 1879 was even drier than usual, and December was also very dry during the first three weeks. Some light showers of little importance were received in the last week of the month, chiefly in the Punjab. January 1880 was also unusually dry. Light showers fell in North-Western India during a period of slight disturbance from the 18th to the 22nd. Light to moderate snow was received in the hill districts during the same period. February was somewhat more disturbed than usual, and the rainfall was above the average, more especially in Bengal, which received frequent heavy thunder showers during the period from the 8th to the 18th. March was a very dry and hot month in North-Western and Central India. In Bengal occasional rain from hot weather storms. The following gives a summary of the rainfall of Northern India for the cold weather period of 1879-80:—

PROVINCE.	Variation from normal of average actual rainfall, 1st December 1879 to 31st March 1880.
	"
Punjab	—1'76
Rajputana	—0'41
Central India	—0'87
North-Western Provinces and Oudh	—0'67
Bengal and Behar	+2'28

PROVINCE.	Variation from normal of average actual rainfall, 1st December 1879 to 31st March 1880.
	"
Assam	+7.58
Central Provinces	—1.46
Berar	—1.14
Bombay	—0.33
Madras	—0.82
Burma	+0.53

The preceding data show that the rainfall of the cold weather period was below the average in North-Western and Central India, the deficiency being greatest in the Punjab. It was on the other hand considerably in excess in North-Eastern India, chiefly due to heavy rain in that area during a storm in February (the third cold weather storm of the season described below).

Storms of the cold weather of 1879-80.—The cold weather of 1879-80 was somewhat more free than usual from storms. The following gives an account of the most important disturbances which crossed Northern India during the period *viz.* the storm of 24th to 28th December, the storm of 17th to the 26th January, the storm of the 8th to 10th February, and the storm of the 15th to the 18th February. The tracks of the last three of these storms are laid down in chart 2, Plate LVI.

(I) Disturbance of the 24th to 28th December 1879.—Weather was fine with clear skies over the whole of India on the 21st, but the barometer was beginning to fall after a rise lasting from the 18th to the 21st. The fall was rapid on the 22nd and 23rd. It continued in North-Western India on the 24th, but ceased in Southern India and Burma.

The effect of this continuous fall was to reduce pressure on the 24th upwards of two tenths below the normal in North-Western India and to develop a low pressure area in Upper Sind. The depression covered Upper Sind on the morning of the 24th. The following observations define its position :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Quetta	"	—179	—278	Calm	1	1
Jacobabad	29.854	—158	—267	NE	1	1
Hyderabad	29.887	—138	—221	WSW	7	1
Bickaneer	29.913	—110	?	S	2	0
Mooltan	29.903	—119	—226	Calm	1	8

Skies were overcast in the Punjab hills, but were clear in the plains of North-Western India.

The disturbance advanced eastwards during the next 24 hours and covered North Rajputana and the South Punjab at 10 A.M. of the 25th. The following observations define its position at that hour:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Murree	*	— ^h 108	— ^h 246	SW	...	10
Mooltan	29'844	— ^h 059	— ^h 285	NW	2	0
Bickaneer	29'905	— ^h 072	?	SW	6	0
Sirsa	29'851	— ^h 063	— ^h 263	S	6	10
Ludhiana	29'853	— ^h 104	?	SSE	1	8
Lahore	29'815	— ^h 161	— ^h 284	E	6	0

Westerly winds prevailed in the North-Western Provinces and Bihar, and north-westerly winds in Bengal. Temperature had risen considerably in the Punjab and Rajputana, more especially at Bickaneer (+6°), Sirsa (+2°) and Sialkot (+4°). Skies were overcast in the hills, but were clear at the great majority of stations in North-Western India. Some showers had fallen in the North Punjab.

26th December.—The observations indicate that the disturbance had filled up during the previous day, and that a second small disturbance was approaching Upper Sind. The following give observations defining the position of this disturbance:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Quetta	*	+ ^h 010	— ^h 258	NE	3	8
Mooltan	29'979	+ ^h 135	— ^h 158	NW	3	0
Jacobabad	29'909	+ ^h 018	— ^h 212	E	15	1
Bickaneer	29'974	+ ^h 069	?	SE	2	5
Kurrachee	29'906	+ ^h 016	— ^h 187	SSW	17	8

The barometer had risen very rapidly in the area covered by the depression on the 25th. Skies were now more or less clouded in Sind and the Punjab. Winds were unchanged in Bengal and Bihar. Local showers had been received in Rajputana and the Punjab during the previous day, but the amounts were generally very small.

27th December.—The observations given below show that the depression had advanced eastwards into North Rajputana:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Murree	...	— ^h 089	— ^h 259	SW	...	10
Bickaneer	29'888	— ^h 086	?	SSW	5	10
Sirsa	29'900	— ^h 050	— ^h 217	SE	5	1
Mooltan	29'932	— ^h 047	— ^h 207	N	5	80
Jacobabad	29'928	+ ^h 019	— ^h 201	Calm	1	7

The observations at Murree show the tendency to the formation of a secondary depression in the North Punjab and the area of depression defined by the isobar of 29·95" hence extended as a trough from Jeypore to the North Punjab. Skies were now overcast over the whole of North-Western India and fairly general rain had fallen in the Punjab and western districts of the North-Western Provinces and showers in Rajputana. Hissar received 2 inches and Rohtak 1·9 inches.

28th December.—A rapid increase of pressure occurred in Upper India and filled up the depression or trough in that area on the 27th. Skies were clear at 10 A.M. in the Punjab, Sind and the greater part of Rajputana. Showers had been received during the previous 24 hours in the Punjab and western districts of the North-Western Provinces. The largest falls were 2·4 inches at Dharmasala and 1·6 inches at Naini Tal.

The disturbance hence consisted of two very shallow depressions which advanced eastwards from Baluchistan or Upper Sind to the foot of the hills. The first was practically rainless and the second gave light to moderate rain to the Punjab and western districts of the North-Western Provinces. The following table gives data of the rainfall during the storm :—

PROVINCE.	AVERAGE ACTUAL RAINFALL OF					TOTAL OF PERIOD.
	24th.	25th.	26th.	27th.	28th.	Inch.
Punjab	<i>Nil</i>	0·07	0·05	0·40	0·16	0·68
Rajputana	<i>Nil</i>	<i>Nil</i>	0·09	0·08	0·08	0·25
North-Western Provinces	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	0·09	0·20	0·29
Oudh	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	0·05	0·23	0·28

(II) Disturbance of the 17th to the 20th January 1880.—This disturbance advance from Baluchistan into Upper Sind on the morning of the 17th. The following gives the average barometric movements in India during the previous three days :—

PROVINCE.	AVERAGE PRESSURE CHANGES IN 24 HOURS PRECEDING 10 A.M. OF		
	15th.	16th.	17th.
Punjab	—·028	—·082	+·013
Sind	—·013	—·089	—·086
Rajputana	—·025	—·111	+·013
North-Western Provinces	—·031	—·062	+·033
Central Provinces	+·024	—·065	—·011
Bengal and Assam	+·032	—·053	+·003
Bombay	+·042	—·028	—·027
Madras	+·020	—·020	—·034
Burma	+·009	—·021	+·001

Pressure had hence been decreasing over nearly the whole of India during the 48 hours preceding the advent of the storm in the Indian area. The fall on the 15th and 16th was greater in the Punjab and Rajputana than in Sind.

The following observations define its position on the morning of the 17th:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Bickaneer	29°880	—°051	?	SSE	7	7
Mooltan	29°870	—°088	—°267	SE	1	0
Jacobabad	29°818	—°128	—°278	ENE	1	4
Hyderabad	29°899	—°082	—°197	SW	?	1

These observations show that the depression at the centre was nearly three tenths of an inch and that the centre was to the east of Jacobabad in about Lat. 28° N. and Long. 69½° E. No rain was recorded in Northern or Central India on the 17th.

18th January.—The 10 A.M. observations show that the depression had advanced slowly eastwards and that the centre was in about Lat. 27½° N. and Long. 73° E. The following observations define its position at 10 A.M. of the 18th:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Sirsa	30°044	+°121	—°216	Calm	4	0
Lahore	29°381	—°053	—°203	E	1	10
Mooltan	29°848	—°022	—°289	NE	1	0
Jacobabad	29°886	+°068	—°204	SSE	1	
Ajmere	29°942	—°004	—°122	S	3	3

Skies were now more or less clouded in the North and East Punjab and the western districts of the North-Western Provinces, and light showers had fallen at one or two stations in the Punjab.

19th January.—The observations at Sirsa, Rawalpindi and other stations in the Punjab on this day and the 20th are erroneous to such an extent as to make it impossible to follow the depression with certainty. Apparently there was a slight tendency to the formation of a secondary depression in the North Punjab on the 19th. The primary depression advanced eastwards on the same day towards the hills. Rain had fallen during the previous 24 hours, chiefly in the eastern districts of the Punjab and in the hill districts of the North-Western Provinces. A rapid increase of pressure occurred on the 20th, and anti-cyclonic conditions were re-established on the morning of the 21st. Showers fell in the hill districts of the North-Western Provinces on the 20th.

The disturbance was hence throughout small and of little importance. It advanced along an easterly track further to the north than usual, and hence it gave rain chiefly to the Punjab and the hill districts. The rainfall in these districts was not large, and, although there was a slight tendency to the formation of a secondary depression, it failed to develop.

(III).—Depression of the 8th to the 10th February 1880.—

This resembled the preceding storm in its chief features. It entered Upper Sind and the South-West Punjab on the morning of the 8th. The following observations define its position at 10 A.M. of that day :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Quetta	?	—'086	—'139	NNW	5	9
Jacobabad	29'917	—'131	—'134	NW	1	1
Mooltan	29'977	—'083	—'097	NE	1	6
Dera Ismail Khan	29'980	—'075	—'094	ESE	1	8

The centre of the shallow depression was in Lat. 29° N. and Long. 70° E.

Skies were clear in Upper India on the morning of the 7th but clouded over in the Punjab during the day and were overcast on the morning of the 8th in that area. Westerly winds prevailed in the Gangetic plain and northerly winds in South Bengal. Showers had fallen in Rajputana.

9th February.—The observations show that the depression had advanced eastwards and that the centre was near, and to the west of, Sirsa at 6 A.M. :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Murree	?	—'080	—'152	S	?	0
Bickaneer	30'026	+ '013	?	SW	2	0
Sirsa	29'925	—'089	—'128	SW	2	6
Lahore	30'002	+ '003	—'069	E	3	10
Mooltan	29'999	+ '022	—'087	NE	3	0

Winds were very light in the area of depression, and in several cases were below their normal strength in February. Skies had cleared in Sind and the West Punjab, but were overcast in the East Punjab, and more or less clouded in the North-Western Provinces. Rain or snow had fallen in the Punjab hill districts and rain in the eastern districts of the Punjab.

10th February.—Pressure had increased rapidly during the previous 24 hours, and there was no indication of the existence of a depression area in Northern India. Weather was, however, slightly disturbed during the next two days in the North-Western Provinces. Bundelkhand received local showers on the 10th and 11th.

High pressure conditions continued until the morning of the 13th, when pressure began to give way in India generally. The following gives a summary of the pressure

changes in different parts of India for the 24 hours preceding 10 A.M. of the 13th and 14th :—

DISTRICT.	AVERAGE CHANGE OF PRESSURE IN 24 HOURS PRECEDING 10 A.M. OF		AVERAGE CLOUD AMOUNT AT 10 A.M. OF	
	13th.	14th.	13th.	14th.
Punjab	—050	—040	9·2	4·8
Sind	—071	—044	8·5	3·5
Rajputana	—058	—062	8·0	1·0
North-Western Provinces	—001	—040	8·2	4·8
Central Provinces	—031	—026	0	0
Bengal and Assam	—015	+018	5·4	2·6
Burma	—005	+006	1·3	0·3
Bombay	—017	+039	0	0·8
Madras	—017	+022	2·2	2·8

The observations of the 13th showed that pressure was falling most rapidly at Quetta and in Sind. This was apparently due to the passage of a shallow depression through Baluchistan. It had perhaps advanced from Central Persia, as Bushire had heavy rain on the 12th.

The disturbance was small and of little importance. It either filled up in Sind or advanced rapidly on the 14th across into North-Western India as a very feeble depression and was absorbed in a larger and more important depression forming on the 14th and 15th in Central India, the account of which is given below.

(IV).—*Depression of the 15th to 18th February 1880.*—The barometric movements as indicated by the observations published in the daily report differ so largely from station to station that it is not possible to trace clearly the progress of a definite depression and disturbance from west to east during this period. This was in part due to the occurrence of numerous hail storms, which are in India directly related to great irregularity of pressure changes. The following gives an analysis of the storm so far as can be judged from the observations in the light of later experience.

The depression apparently formed in Central India and Berar. There is no evidence of the passage of a definite and well marked cyclonic circulation eastwards from Baluchistan or Sind into this area. The following observations define its position at 10 A.M. of the 15th :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 15°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Indore	29·736	—0133	—0178	W	5	4
Neemuch	793	—0145	—0195	SSW	2	0
Jubbulpore	768	—0176	—0252	S	3	3
Jhansi	793	—0191	—0216	SSE	1	0
Ajmere	008	—0181	—0219	SE	3	0

The winds were very irregular in this area and show that there was no cyclonic circulation at this period. Skies were more or less clouded over the whole of Northern and Central India.

16th February.—The observations of this day indicate that the depression in Berar and Central India on the previous day had advanced eastwards into the central districts of the Central Provinces, and that a subsidiary depression was forming in Upper India.

The following observations fix the probable position of the primary depression :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previ- ous 24 hours.	
Raipur	29'877	—'016	—'089	W	23	8
Benares	'825	—'078	—'179	E	6	10
Allahabad	'818	—'081	—'203	ESE	5	9
Jubbulpore	'812	+ '044	—'208	W	4	8
Seoni	'798	+ '043	—'170	NW	6	5

The centre of this depression was some distance to the north of Jubbulpore. A subsidiary depression was forming in the south-eastern districts of the Punjab, as is shown by the following observations :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previ- ous 24 hours.	
Sirsa	29'798	—'036	—'233	NW	3	10
Delhi	29'749	—'090	—'260	SW	5	7
Roorkee	29'759	—'092	—'242	SE	6	10
Sialkot	29'787	—'120	—'227	NNW	1	5
Peshawar	29'800	—'125	—'253	NW	3	0
Mutree	?	—'117	—'280	SW	?	8
Chakrata	?	—'179	—'250	Calm	1	10

The decrease of pressure was hence more marked at the hill stations than at the plain stations. Winds were light at the level of the plains. Heavy rain had fallen at Simla and Chakrata and showers in the eastern districts of the Punjab and the hill districts of the North-Western Provinces and Oudh. Naini Tal had received 4·1 inches. Thunderstorms with hail were reported at several stations in the North-Western Provinces.

An independent disturbance of the usual hot weather type was also giving at this time numerous thundershowers and fairly general rain to Assam and Benal.

17th February.—The primary depression continued to advance eastwards and was in the eastern districts of the Central Provinces at 10 A.M. The following observations fix its position at that hour:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Cuttack	29°830	—°013	—°157	SSW	5	9
Sambalpur	°800	+°006	?	Calm	0	9
Hazaribagh	°886	+°029	—°092	ESE	9	10
Allahabad	°849	+°031	—°176	E	5	10
Jubbulpore	°830	+°018	—°190	W	3	7

The wind data show feeble cyclonic circulation about a centre to the north of Sambalpur. Winds were very irregular in Bengal.

The position of the secondary depression is shown by the following observations:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Murree	?	—°046	—°329	ENE	?	10
Chakrata	?	—°044	—°302	E	6	10
Delhi	29°696	—°053	—°333	SE	5	10
Roorkee	°725	—°034	—°288	SE	5	9
Sialkot	°712	—°075	—°313	ESE	3	10
Rawalpindi	°674	—°108	—°396	NW	?	10
Lahore	°695	—°123	—°348	NE	2	0
Ludhiana	°696	—°058	—°337	ENE	1	10
Sirsa	°685	—°113	—°344	W	6	10

The depression had hence extended north-westwards along the foot of the hills, and had also deepened so that the amount of the depression in the central area ranged from three to four tenths. Strong winds were now blowing in North-Western India and at the hill stations. There was much cloud, but it was very irregularly distributed. Duststorms and hailstorms were reported by several stations. Fairly general rain had fallen in the east and south of the Punjab, and the greater part of the North-Western Provinces and Oudh. Amounts of 2 inches or upwards were received at Ludhiana, Simla and Naini Tal.

18th February.—A very rapid recovery of pressure, ranging from '12" at Allahabad to three-tenths of an inch in the North Punjab, had occurred during the previous 24 hours, and obliterated the subsidiary depression in Upper India, and fine clear dry weather had set in again over that area.

The primary depression had almost certainly been transferred to South and Central Bengal. The following observations indicate its character and position at 10 A.M. :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Saugor Island	29.766	—0.95	—2.13	W	7	3
Chittagong	796	—1.28	—1.87	S	3	8
Dacca	789	—1.42	—1.96	S	5	10
Jessore	796	—1.20	—1.74	N W	7	10

Strongish winds were blowing in Bengal. Dry westerly winds had recommenced in the Gangetic plain, and skies were clear in Northern India except in Bengal. General rain had fallen in Assam and Bengal during the previous 24 hours.

A rapid recovery of pressure followed in Bengal during the day, and fine weather with clear skies and westerly winds extended from the Gangetic plain into Bengal on the morning of the 20th.

The storms of the cold weather period of 1879-80 were hence very feeble and diffused disturbances, the cyclonic circulation in which at the level of the plains was very irregular. They are, however, examples of the smaller cold weather disturbances, and are interesting as showing the tendency in these feeble storms to the development of deep subsidiary depressions in Upper India.

1880-81.

Chief abnormal features of the meteorology of India in 1880.—The cold weather of 1879-80 was marked by deficient pressure in the Indian region. January 1880 was considerably drier than usual. February was chiefly remarkable for a heavy burst of rain in East Bengal. March, April and May were very dry and hot months in North-Western and Central India. Pressure was in defect over the Indian area in May by moderate amounts, and was locally in defect in Upper India. The anomalies were small over the remainder of India except on the coast of the Konkan, where there was a tendency to local excess of pressure.

The south-west monsoon rains commenced unusually early in Bengal on the 2nd of June and about the normal date, *viz.* the 6th, on the Bombay coast. The Bengal current was strong and the Bombay current slightly feebler than usual. The rains in North-Western and Western India were very irregularly distributed in July and August. North-Eastern India and Burma received abundant or normal rainfall. There was a general break in the rains during the greater part of August (or from the 14th to the end of the month), which was most marked in North-Western and Western India, and was apparently the result of an exceptional fall of snow in July in the North-West Himalayas. This break ended about the 3rd of September, and moderately heavy rain was received during the next ten or twelve days over nearly the whole of Northern and Central India. The monsoon current withdrew from Upper India about the 19th of the month.

The rainfall of August and September was hence very deficient over the whole of North-Western India.

Pressure from September to December was in excess over the Indian region, the excess increasing in amount during the period and averaging $+0.33$ " in November and December.

Pressure was locally in defect in the peninsula and in excess in Northern India during the months of October and November. The retreating south-west monsoon rains set in on the Coromandel Coast about the 18th of October, and the whole of Madras and the Deccan received excessive rain in November. Normal rain was received in the Carnatic and Southern India in December, and the south-west monsoon retreated from the Bay about the 25th of the month. The distribution of the south-west monsoon rainfall is shown by the following data:—

DISTRICT.	VARIATION FROM NORMAL OF	
	Ordinary south-west monsoon rainfall, June to September 1880.	Retreating south-west monsoon rainfall, October to December 1880.
Punjab	—1.84	—0.47
North-Western Provinces	—0.62	—0.41
Bengal and Bihar	+3.53	+0.79
Assam	+2.03	+1.14
Central Provinces	+0.88	+1.45
Berar	—7.97	+2.33
Rajputana	—2.04	+0.51
Central India	—6.98	+1.12
Bombay	—5.90	+1.02
Madras	—3.12	+7.24
Burma	+2.45	—4.94

The table shows that those parts of India which receive their chief rainfall from the Arabian Sea monsoon current had a fall, more or less, below the average, whilst those dependent mainly on the Bay of Bengal current received amounts more or less in excess.

The following states the chief meteorological features which probably influenced the cold weather rainfall of 1880-81:—

- 1st.—The Bombay branch of the south-west monsoon circulation was weaker than usual, whilst the Bengal current was abnormally strong. Hence North-Western and Western India received less than their normal amounts, whilst nearly the whole of North-Eastern India and Burma obtained larger amounts than the normal.
- 2nd.—The retreating south-west monsoon rains were also more abundant than usual in Madras and the Deccan. They were excessive in November and above the normal to a moderate extent in October and December.
- 3rd.—During the months of November and December there was a general excess of pressure in the Indian area. It was larger in amount at the level of the plains than the hill stations in Upper India, and was hence a feature

of the lower atmospheric strata chiefly. With respect to the general condition pressure was locally in defect in Upper India and in excess in the peninsula.

4th.—The abnormal pressure conditions of the whole cold weather period were very marked and unusually persistent. The most important pressure conditions of the period were:—

(a) General excess of pressure in the Indian area. The following gives data:—

Month.	Variation of mean pressure of Indian land area from the normal.
September 1880	+ '008"
October "	+ '013"
November "	+ '033"
December "	+ '034"
January 1881	+ '038"
February "	+ '021"
March "	+ '028"

(b) Pressure was during nearly the whole period in relative defect at all the hill stations except Leh as compared with the neighbouring plain stations, but the deficiency was small, except in March. At Leh pressure was on the other hand more or less considerably in excess from October to February. The following gives comparative data:—

MONTH.	VERTICAL PRESSURE ANOMALY.			
	Leh muuz Lahore.	Murree muuz Peshawar.	Chakrata muuz Roorkee.	Ranikhet muuz Bareilly.
September 1880	—'025	—'031	—'037	—'028
October "	+ '034	+ '013	—'003	0
November "	+ '001	—'010	—'048	—'040
December "	—'021	—'031	—'052	—'010
January 1881	+ '056	—'018	—'027	—'001
February "	+ '088	+ '030	+ '011	+ '017
March "	—'082	—'051	—'064	—'048

Chief features of the meteorology of the cold weather period, 1880-81.—The following extract from Mr. Blanford's report on the meteorology of the year 1881 gives a general view of the chief features of the meteorology of the months of January, February and March 1881.

"At the beginning of the year the atmospheric pressure was very considerably and persistently above the normal average—a condition characteristic of the whole of the cold season of 1880-81, being in fact a legacy from the rainy season immediately preceding. Hence January and February were both dry months; but little rain fell on the plains of North-Western India, and but little snow on the surrounding mountain tract. The temperature of January, like that of the two preceding months, was above the average in Western India, and especially in the Punjab; and below it in Bengal and the provinces around the Bay. The high temperature of the former was due partly to the absence

of rain, partly to the prevalence of southerly winds; principally, probably, to the former cause; for it has been shown in the Report for 1879 that, except in the months of November and December, anomalies of temperature in India are chiefly dependent on the cloud and rainfall; and the comparative absence of both cloud and rain in Northern India were very striking. In February the much greater excess of mean temperature in Northern India must be attributed mainly to the fact that in North-Western India there was scarcely any rain before the 19th of the month, while up to that time south winds were very prevalent, and that, except in the Punjab, the total fall was much below the average. The fall of temperature in the latter part of the month was insufficient to neutralize the combined effects of dryness and southerly winds during the greater part of the first three weeks.

In March the excessive pressure continued on the plains of India undiminished, but only on the plains; being in fact due to the abnormally high density of the lower atmospheric strata; whereas in February it had been entirely owing to the condition of the higher strata. The southerly winds which had prevailed through the previous months in an abnormal degree now resulted in rain in quantity considerably exceeding that usual at the season; and the effects of the fall of temperature which had set in at the end of February lasted throughout the month, being renewed by the further rainfall, at intervals of a few days. Hitherto but little snow had fallen on the North-West Himalayas, but in the beginning of this month 5 feet was measured at Murree, and a few days later another fall took place of about half this quantity. Nevertheless the total snowfall of the cold season was very moderate."

The following gives rainfall variation data for the cold weather period :—

PROVINCE.	VARIATION FROM NORMAL.				Total variation of period.
	December.	January.	February.	March.	
	"	"	"	"	"
Punjab	+0.11	-0.81	-0.23	+0.89	-0.04
North-Western Provinces and Oudh . . .	+0.04	-0.73	-0.40	+1.21	+0.12
Rajputana	-0.04	-0.03	-0.19	+0.39	+0.13
Central India	-0.01	-0.46	-0.23	+0.62	-0.08
Central Provinces	+0.24	-0.46	-0.32	+1.85	+0.83
Bengal	+0.02	-0.46	-0.81	+1.77	+0.52
Assam	+1.05	-0.62	-0.80	+0.39	+0.04

The preceding variation data show that the rainfall of the cold weather period was in general defect in North-Western and Central India in January and February. The rainfall of March was considerably above the average, mainly due to a storm of the cold weather type in the first week of the month. The rainfall of the whole period was hence approximately normal in North-Western and Central India and in slight excess in Bengal and the Central Provinces.

Storms of the cold weather period, 1880-81.—This period was unusually free from cold weather storm. There was a feeble disturbance in the third week of December 1880. The only important storm of the whole period occurred in the first week of March. It advanced across Northern India from Baluchistan to Upper Burma. Its track is given in Chart 3, Plate LVI. The following gives an account of these two disturbances :—

(1)—*Disturbance of the 14th to the 16th December 1880.*—This was a very small and feeble disturbance. An area of depression formed in West Rajputana on the 12th and 13th.

The following observations show the position of the depression on the morning of the 14th :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Bhuj	30°068	—°006	?	WNW	7	4
Deesa	30°058	—°014	+°020	Calm	8	5
Bickaneer	30°011	—°010	?	S	6	9
Mooltan	30°180	+°061	+°085	NE	?	4
Jacobabad	30°088	+°033	Nil	ESE	2	9

A large number of stations in Bihar and, the North-Western Provinces had calms. Northerly winds obtained in Bengal. Skies were clouding over in North-Western India.

The depression shifted slightly to the west during the day. Its position at 10 A.M. of the 15th is indicated by the following data :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Deesa	30°045	—°013	—°013	WSW	7	9
Bickaneer	29°940	—°010	?	SSW	6	9
Sirsa	29°993	—°118	—°107	SE	10	10
Lahore	30°027	—°154	—°088	E	2	10
Mooltan	30°057	—°123	—°071	NNE	4	10
Murree	?	—°154	—°122	SW	?	10

The barometer had hence fallen rapidly in the Punjab (most rapidly at Lahore and Murree) and a long trough of shallow depression ran from Deesa to the North Punjab. This was evidently due to the tendency to the formation of a secondary depression, which did not however develop beyond the initial stage. Skies were overcast in North-Western India and general moderate rain had fallen in the Punjab and western districts of the North-Western Provinces.

16th December.—A very shallow depression covered North Rajputana and a second one the North Punjab. The following gives data :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Bickaneer	29°986	+°046	?	S	5	0
Sirsa	30°046	+°053	—°070	Calm	5	10
Mooltan	30°059	+°002	—°084	Calm	2	6
Lahore	30°082	+°055	—°052	WSW	2	10
Peshawar	30°068	+°004	—°081	W	3	8
Rawalpindi	?	?	?	N	1	0
Murree	?	—°038	—°169	SW	?	8

Skies were still clouded over the greater part of North-Western and Central India, but had cleared at Quetta and in Sind. Light showers had been received in the East Punjab, Rajputana and the North-Western Provinces, but amounts were generally small.

A rapid rise of pressure occurred over the whole of India during the next 24 hours. It ranged from '10" to '13" in North-Western India. The depression hence disappeared before the 17th, and fine clear weather obtained over the whole of Northern India.

The disturbance hence almost certainly originated in Rajputana, and was nearly stationary during its existence. There was a tendency to the formation of a secondary depression in the North Punjab, but it was slight, and the whole disturbance was hence feeble. It gave a moderate fall of rain on the 15th and 16th to the Punjab and North-Western Provinces. The following gives data:—

PROVINCE	AVERAGE ACTUAL RAINFALL.		TOTAL.
	15th.	16th.	
Punjab	0'56	0'06	0'62
North-Western Provinces	0'12	0'19	0'31
Oudh	0'04	0'04	0'08

As the depression was almost stationary during its existence, its track is not given in the cold weather storm tracks of the year.

It may be noted that in dry cold weather seasons there is frequently a strongly marked tendency to the formation of shallow depressions in Rajputana which are either stationary or more slowly to the eastward. They are generally almost rainless, but in some cases give light to moderate showers in the submontane districts of the East Punjab and Upper North-Western Provinces.

The cold weather of 1880-81 furnished several examples. The storm described above is an instance. The second storm of the class in the cold weather occurred during the first week of January. Light south-easterly winds set in at the end of December over the North-Western Provinces, whilst north-westerly to westerly winds continued in Bengal. On the morning of the 2nd a very shallow depression covered Rajputana. Light showers had fallen in the North Punjab, and skies were more or less clouded in the Punjab. Pressure increased rapidly in the Punjab and Sind during the day, and on the morning of the 3rd the depression had nearly disappeared. It covered South Rajputana. Rain had fallen during the previous 24 hours in the East Punjab and western districts of the North-Western Provinces. Pressure increased during the day over the whole of North-Western India, and the observations of the 4th showed that the depression was no longer in existence.

The depression was too small to be classed amongst the cold weather storms given in the list, and is only interesting as an example of a depression forming in North-Western India. It gave light rain to Upper India and moderate snow showers in the adjacent mountain districts.

Pressure fell rapidly in India on 28th of January, and a shallow depression appeared in Rajputana on the morning of the 29th. It remained almost unchanged in position

on the 30th and 31st, and disappeared before the morning of the 1st. No rain fell in Upper India during the existence of the depression.

Again on the 8th February pressure gave way rapidly in Northern India, and a shallow depression formed in East Rajputana. It was practically stationary in position from the 9th to the 11th, and then disappeared. It gave no rain in Upper India.

Again on the 13th a shallow rainless depression formed under the same conditions as the preceding in Rajputana. It filled up on the 15th.

(II).—*Storm of the 2nd to the 6th March 1881.*—On the morning of the 27th of February the weather was fine and settled, and skies clear over the whole of India, except the north-western districts, where they were partially clouded. The barometer, which had been very high for some days, was however commencing to fall rapidly. During the next 24 hours the fall was general over the whole of India. The following gives the average amount of the fall in different parts of India :—

PROVINCE.	Average fall of barometer during 24 hours ending 10 A. M. of 28th February.
Punjab	—'097
Sind	—'095
Rajputana	—'034
North-Western Provinces	—'067
Central Provinces	—'078
Bengal and Assam	—'049
Bombay	—'041
Madras	—'062
Burma	—'028

Skies were clouding rapidly in Upper India and weather was dull. Pressure continued to give way during the succeeding 24 hours, but the changes were smaller than on the previous day. The following table gives the changes in the same form as for the preceding day :—

PROVINCE.	Average fall of barometer during 24 hours ending 10 A. M. of 1st March.
Punjab	+ '010
Sind	—'022
Rajputana	—'055
North-Western Provinces	—'019
Central Provinces	—'003
Bengal	—'014
Bombay	—'046
Madras	—'005
Burma	—'027

Temperature was also increasing rapidly in Sind, the Punjab and Rajputana, and was on the average 5° higher on the 1st March than on the 28th February.

Some very light showers had fallen in Sind and the Punjab. Light westerly winds prevailed in the Gangetic plain and Central Bengal, and variable irregular winds in Upper and Central India.

During the next 24 hours (preceding 10 A.M. of the 2nd) pressure gave way briskly to rapidly over the whole of India, and the 10 A.M. observations showed that a depression was approaching Sind from Baluchistan or was forming in that area. The following give data of the mean pressure changes of the preceding 24 hours in different parts of India:—

DISTRICT.	Average fall of barometer during 24 hours ending 10 A.M. of 2nd March.
	Inch.
Punjab	—'086
Upper Sind	—'184
Rajputana	—'053
North-Western Provinces	—'078
Central Provinces	—'071
Bengal and Assam	—'062
Bombay	—'005
Madras	—'031
Burma	—'002

The large fall in Upper Sind was apparently due to a disturbance which was advancing across the Sind frontier at this time.

The following are the observations at the stations where the fall was greatest:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Quetta	?	?	?	E	6	8
Kurrachee	29'860	—'094	—'084	SW	11	6
Jacobabad	'832	—'184	—'113	WSW	3	3
Mooltan	'908	—'160	—'077	SE	2	10
Dera Ismail Khan	'947	—'109	—'058	NE	1	10

These observations indicate that there was a fairly well-marked but shallow depression in Upper Sind and the adjacent districts of Baluchistan, the centre of which was near and a little to the north-west of Jacobabad.

A shallow depression had also formed during the preceding 48 hours in South-West Rajputana and the western states of Central India, Khandesh and the north-Western districts of the Central Provinces. The following 10 A.M. observations of the 2nd define the position of that depression at that hour:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Mean hourly velocity previous 24 hours.	
	"	"	"			
Deesa	29·863	—·073	—·082	NNE	10	9
Surat	·873	—·020	—·055	NNW	8	2
Malegaon	·815	—·059	—·090	NW	8	9
Khandwa	·814	—·094	—·055	SW	6	8
Hoshangabad	·834	—·125	—·091	Calm	7	6
Akola	·845	—·045	—·033	SSW	4	0

This was clearly a separate depression to that entering Sind, and it will be observed that it formed in an area in which there had been a very strongly marked tendency to the formation of shallow depressions during the previous two months. It is a striking example of the principle of the repetition of abnormal meteorological conditions and disturbances in the same area that forms one of the more important features of the meteorology of India.

Skies were now overcast at the hill stations and in the Punjab, North Rajputana and the western districts of the North-Western Provinces, and were lightly clouded in Sind. Light local showers had fallen at Quetta and Kurrachee and in the Punjab.

A rapid rise of temperature had occurred in North-Western India which was most marked at the following stations:—

STATION.	VARIATION OF			Change of mean temperature in past 24 hours.
	Maximum temperature from normal.	Minimum temperature from normal.	Mean temperature from normal.	
	0	0	0	0
Peshawar	+0·8	+7·9	+4·4	+ 6·3
Mooltan	—3·4	+8·0	+2·3	+ 4·5
Sirsa	0	+6·3	+3·2	+ 8·9
Ajmere	+1·2	+7·0	+4·1	+11·1

3rd March.—The barometric movements of the previous 24 hours were chiefly due to the rapid advance of the primary depression entering Sind on the 2nd into South-East Rajputana and Central India, its combination with the previously existing depression and disturbance in that area, and the formation of a subsidiary or secondary depression in the North Punjab.

The following observations define the position of the primary depression:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Jubbulpore	29.834	—'072	—'060	SSE	5	2
Nowgong	'860	—'067	—'102	SE	1	10
Jhansi	'860	—'022	—'095	ENE	4	4
Saugor	'792	—'074	—'107	W	2	43
Hoshangabad	'828	—'039	—'098	WSW	6	0

The depression hence covered the eastern districts of Central India and the north-eastern districts of the Central Provinces, and the centre was a little to the north of Saugor. If this was the continuation of the depression entering Sind on the 2nd, it had advanced about 550 miles in an east-south-east direction during the previous 24 hours. As the depression which was in Central India on the preceding day was no longer in existence as a separate disturbance, it is almost certain the disturbance entering Sind on the previous day had advanced towards and been absorbed into the depression in Central India. This probably accounts for its exceptionally rapid advance during the previous 24 hours.

Skies were clear over the whole of the primary depression, and no rain had fallen during the previous 24 hours in Rajputana, Sind and Central India.

The position and character of the secondary depression in Upper India are shown by the following observations:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Lahore	29.769	—'128	—'189	W	4	10
Rawalpindi	707	—'102	—'167	E	4	10
Peshawar	'734	—'189	—'294	Calm	2	8
Dehra Ismail Khan	'801	—'146	—'190	WNW	1	3
Murree		—'160	—'255	Calm	7	10

A well-marked depression had hence formed in the North Punjab. Skies were heavily clouded in the Punjab and western districts of the North-Western Provinces, but were clear or lightly clouded in Sind and Rajputana. General rain, moderate to heavy in amount, had fallen in the Punjab hill districts as well as in the Punjab and western districts of the North-Western Provinces. Sirsa reported 1.82 inches, Simla 1.75 inches and Murree 1.47 inches.

A very rapid decrease of temperature had occurred during the previous 24 hours over the whole of North-Western India. The following gives the most striking examples:—

STATION.	VARIATION OF			Change of mean temperature during preceding 24 hours.
	Maximum temperature from normal.	Minimum temperature from normal.	Mean temperature from normal.	
Dehra Ismail Khan	—16·8	+1·0	—7·9	—9·4
Delhi	—18·4	+1·1	—8·7	—8·8
Lahore	—16·9	+4·3	—6·3	—6·9
Peshawar	—8·9	+3·6	—2·7	—6·7

4th March.—The barometer began to rise rapidly on the morning of the 4th, and at 10 A.M. the secondary depression in the Punjab had partially filled up and was no longer of any importance. Skies had also cleared over the whole of the Eastern Punjab, except in the districts near the hills, and were also clearing there and in the hill districts. Some light showers had fallen in the Punjab and western districts of the North-Western Provinces, the largest amount recorded being 1·45 inches at Bareilly.

The primary depression was passing through the north-eastern districts of the Central Provinces and entering Chota Nagpur on the morning of the 4th. The following data for that hour show its position:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Sambalpur	29·789	—·057	?	SW	1	4
Hazaribagh	·720	—·164	—·147	WSW	6	8
Benares	·770	—·112	—·123	SE	2	5
Jubbulpore	·811	—·023	—·083	NW	4	10
Raipur	·776	—·073	—·111	NW	11	0

Skies were more or less clouded in the Central Provinces, Bihar, Chota Nagpur and Bengal, and light thundershowers had been received in Bihar and Chota Nagpur. With the advance of the primary depression and the filling up of the secondary depression dry cool westerly winds were setting in over the whole of North-Western India.

The following gives the most noteworthy examples of the reduction of temperature:—

STATION.	VARIATION OF			Change of mean temperature in past 24 hours.
	Maximum temperature from normal.	Minimum temperature from normal.	Mean temperature from normal.	
Roorkee	—14·6	—1·7	—8·2	—5·7
Jacobabad	—9·4	+0·4	—4·5	—5·7
Deesa	—4·1	—3·3	—3·7	—4·7

These examples show that the reduction at this period was chiefly in the day temperature. The decrease in the amount of aqueous vapour was very large at many stations, and more especially at the following :—

STATION.	Aqueous vapour pressure at 10 A.M. of 3rd.	Aqueous vapour pressure at 10 A.M. of 4th.	Change during 24 hours preceding 10 A.M. of the 4th.
Ajmere	'523	'162	—'361
Kurrachee	'445	'181	—'264
Deesa	'600	'257	—'343
Sirsa	'532	'357	—'175

5th March —The barometer during the previous 24 hours had risen rapidly over the whole of North-Western and Central India. A slight fall had occurred in Bengal, and a shallow depression, which was evidently the continuation of the disturbance in the eastern districts of the Central Provinces on the previous day, covered the southern and central districts of Lower Bengal at 10 A.M. The following observations define its position :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Saugor Island	29'781	—'005	—'107	SW	16	0
Dacca	'785	—'058	—'109	S	?	9
Berhampore	'808	+ '002	—'133	E	3	10
Calcutta	'775	+ '022	—'120	N	6	

Skies had cleared over the whole of the North-Western Provinces, Bihar and Central India, and north-westerly winds had set in and extended over the whole of the Gangetic plain as far east as Bihar. A rapid decrease of temperature had occurred in Rajputana, the Punjab and western half of the North-Western Provinces, which had reduced the mean temperature of the day on the average to $7\frac{1}{2}^{\circ}$ below the normal of the day.

A very rapid decrease in the amount of aqueous vapour was caused by the setting in of the westerly winds in the North-Western Provinces.

The following gives examples :—

STATION.	AQUEOUS VAPOUR PRESSURE, AT 10 A.M. OF		Change in 24 hours preceding 10 A.M. of 5th.
	4th.	5th.	
Agra	'546	'351	—'195
Lucknow	'551	'444	—'107
Allahabad	'521	'370	—'151

Showers had fallen during the previous 24 hours in Bihar and the North-Western Provinces, chiefly in the districts at the foot of the hills.

6th March.—The slight disturbance passed eastwards into Upper Burma on the morning of the 6th. This is, in the absence of observations in Burma, chiefly indicated by the observations at Sibsagar, Silchar and Chittagong on the 6th and 7th. The following gives the changes for the 24 hours preceding 10 A.M. of the 6th and 7th :—

STATION.	CHANGE OF PRESSURE DURING 24 HOURS ENDING 10 A.M. OF	
	6th.	7th.
Sibsagar	—'018	+ '222
Silchar	+ '019	+ '144
Chittagong	+ '065	+ '084

The changes indicate clearly that a barometric disturbance passed eastwards on the 6th, and that it probably filled up during the day, thus giving rise to the rapid local increase of pressure in Assam and East Bengal registered on the 7th.

Local showers fell in Bengal and Assam on the 5th. The disturbance ceased to give rain after the morning of the 6th.

The following are the chief features of the disturbance :—

1st.—It was a double disturbance, consisting of a long-lived primary disturbance which crossed Northern India and of a secondary short-lived but deepish depression in the Punjab.

2nd.—The following gives approximately the position of the central area of the primary disturbance :—

DATE.	POSITION OF CENTRAL AREA.		Distance travelled during 24 hours.
	Lat. N.	Long. E.	
2nd	28½	68	Miles. ...
3rd	24½	79	725
4th	24	83½	300
5th	23	89	360

It hence drifted nearly due east on the 3rd, 4th and 5th across the head of the peninsula with an average rate of about 462 miles per diem.

3rd.—The secondary depression formed in the Punjab, whilst the primary depression was advancing eastwards across Rajputana. This depression, which covered the North Punjab and was upwards of 3 inch in depth, formed in 24 hours and filled up equally rapidly in the next 24 hours.

4th.—The rainfall which accompanied the disturbance was throughout in the area to the north of the track. Practically none fell to the south.

The following gives average rainfall data of the period of the storm from the 2nd to the 6th:—

PROVINCE.	AVERAGE ACTUAL RAINFALL OF PROVINCE ON					TOTAL OF PERIOD.
	2nd.	3rd.	4th.	5th.	6th.	
Punjab	0'37	0'81	0'19	Nil	0'05	1'42
Rajputana	0'03	0'03	Nil	Nil	Nil	0'06
Central India	0'04	Nil	Nil	Nil	Nil	0'04
North-Western Provinces	0'05	0'30	0'22	Nil	Nil	0'57
Oudh	Nil	0'05	0'09	Nil	0'05	0'19

There were two periods of disturbance during the remainder of the month, *viz.*, from the 16th to the 20th and 26th and 27th.

These disturbances originated in India itself and belonged to the class of hot weather storms, and are hence not included in the list of cold weather storms.

1881-82.

Chief abnormal features of the meteorology of India in 1881.—The cold weather months of January and February 1881 were unusually dry, and temperature was hence considerably above the normal. March was more disturbed than usual, and large amounts of rain fell in the Punjab, the North-Western Provinces and Rajputana, and temperature was very considerably below the normal in Northern India. April and May were somewhat hotter than usual, but the conditions were approximately normal. During the whole of this period pressure was steadily in excess in India, and was in local defect in Burma and Assam and North-Eastern India generally, and in excess in the Peninsula, more especially the Central Provinces, Berar and Konkan.

The Bengal current set in early,—about the 2nd of June. The Bombay current was feeble during the month of June. Pressure fell in North-Western India, and was considerably below the normal during the remainder of the rains. Northern India and Burma received normal or excessive rainfall from June to August, whilst the rains were more or less deficient in the Peninsula. September was a very dry month, more especially in the north-western and western districts of India, as the monsoon currents retreated from Upper India in the first week of September. North and East Bengal received very heavy rain in that month. October was also very dry in North-Western India, and the rains partially failed in the Carnatic. Bihar and West Bengal received larger amounts than usual, and East Bengal and Burma normal rainfall. Madras obtained heavy rain in November and South Madras in December, chiefly due to cyclonic storms.

November and December were rainless months in North-Western India.

Hence the rainfall of the south-west monsoon period was more or less in excess in Northern India (except Assam), Burma, the Central Provinces and Berar. It was in defect in Madras and Mysore.

The following table gives the variations of the rainfall of the whole south-west monsoon period from the normal in the various Provinces of India :—

PROVINCE.	VARIATION FROM NORMAL OF	
	Ordinary south-west monsoon rainfall, June to September 1881.	Retreating south-west monsoon rainfall, October to December 1881.
Punjab	Inches. + 1'37	Inches. —1'14
Rajputana	+ 1'51	—1'18
Central India	+ 3'30	—0'91
North-Western Provinces and Oudh	+ 0'70	—0'81
Bengal	+ 2'26	—1'06
Assam	— 1'04	—2'65
Central Provinces	+ 4'86	—0'43
Berar	+ 11'02	+ 0'65
Bombay	+ 2'66	+ 0'01
Madras	— 5'54	—3'70
Burma	+ 6'87	+ 0'15

The chief features of the meteorology of India in 1881, which may have influenced the character of the cold weather rains and storms of the season 1881-82, are as follows :—

1st.—The Bombay south-west monsoon current was slightly weaker than usual throughout the whole season, and hence the rainfall of Madras and the Deccan was more or less in defect. The Bengal current was of normal strength, and gave normal to abundant rain to North-Eastern India and Burma from June to September.

2nd.—The retreating south-west monsoon rains did not set in over the Carnatic till the beginning of November, but were normal in amount or in slight to moderate defect in November and December.

3rd.—Pressure in the Indian region was below the normal to a moderate extent in October ($-0.023''$) and November ($-0.030''$), and was practically normal in December ($-0.001''$). The chief local feature at this time was a deficiency of pressure in the east and south of the Bay, but this disappeared during the month of December. The pressure anomalies in Northern India were small in amount and not very persistent. There was, however, a tendency towards the establishment of deficient pressure in North-Western India. It was marked in October and November and disappeared in December. It however again came into prominence in January 1882, and finally disappeared in February.

4th.—The anomalies of the hill stations in Northern India were almost identical in amount with those at the neighbouring plains stations. The pressure conditions of the Indian area in December were hence not marked by any large

or important features, and differed very little from the normal. The following gives data for five pairs of stations :—

	VERTICAL PRESSURE ANOMALY.				
	Leh minus Lahore.	Murree minus Peshawar.	Simla minus Ludhiana.	Chakrata minus Roorkee.	Ranikhet minus Bareilly.
October 1881	+ '030	+ '030	+ '004	+ '001	+ '037
November „	+ '027	+ '025	+ '040	+ '017	+ '002
December „	+ '006	+ '004	+ '038	+ '011	+ '036
January 1882	+ '003	+ '006	?	0	+ '018
February „	+ '022	+ '021	?	+ '022	+ '006

5th.—Temperature was considerably above the normal in North-Western India from October to December, the excess being marked at the hill stations, for which it averaged $3\frac{1}{2}^{\circ}$ and in the Punjab where it averaged $2\frac{1}{2}^{\circ}$. Westerly winds were unusually preponderant at the hill stations in Upper India, and the air was abnormally dry over the whole of North-Western and Central India.

Chief features of the meteorology of the cold weather period, 1881-82.—

The following brief sketch is taken from the annual report on the meteorology of India for the year 1882 :—

“The early portion of the winter of 1881-82 was very dry in Northern India, and the temperature, which had been above the average in December in North-Western, Western and Central India, became still more excessive in January and most so on the North-Western Himalaya.

“Meanwhile the westerly winds of the Gangetic plain and the Eastern Punjab which had been unusually steady in December 1881 nearly died away.

“In the Punjab the atmosphere was of unusual calmness, and light southerly winds began to be felt on the Rajputana plateau, bringing up vapour from the warmer region to the south and little by little increasing the cloudiness of the skies of North-Western India. Before the middle of the month a barometric depression of the usual winter type had formed in Western Rajputana, and rain fell in the Central and Eastern Punjab, the Meerut Division of the North-Western Provinces and the northern states of Rajputana. There was another fall of rain at the end of the month in nearly the same region.

“The rain was repeated in February, chiefly on the Himalaya and in North-Western and Eastern India and Rajputana, and especially on the North-Western Himalaya. The temperature was low and the pressure everywhere also below the average. In the Punjab the air was still calm, but the north-west winds prevailed very steadily on the plateau of Rajputana and Central India. Here accordingly, and indeed over the whole of Western and Central India, the air was dry, the skies comparatively cloudless and no rain fell, while on the North-Western Himalaya both cloud and damp were in excess of the average, and the temperature was abnormally most depressed.

“March was a very dry month, especially in North-Western, Western and Central India. The pressure again became above the average, except in Bengal, Assam and the Gangetic plain, and the land winds prevailed to the west and south of this region of relative depression with great steadiness, bringing as usual a dry and cloudless atmosphere; but the temperature of the land surface being now heightened by the sun's ascending declination, instead of this region having a lower than the average temperature, the heat rapidly became excessive. A few showers still fell on the North-Western Himalaya and in the central and western districts of the Punjab, and there was more than the usual amount of rain in Northern Bengal and Assam, but it was restricted to the mountains or the portion of the plains immediately adjacent to their foot.”

The following table gives the variations of the rainfall of the cold weather period of 1881-82 from the normal in Northern and Central India :—

STATION.	Variation from normal of average actual rainfall for period, 1st December 1881 to 31st March 1882.	Percentage variation.
	Inches.	
Punjab	—0·87	—24
Rajputana	—0·52	—65
Central India	—0·72	—65
North-Western Provinces and Oudh	—1·49	—71
Bengal	—0·13	—4
Assam	+2·62	+42
Central Provinces	—1·38	—86
Berar	—0·69	—57

The precipitation of the cold weather period, 1881-1882, was more or less below the normal over the whole of Northern and Central India, except Assam and North and East Bengal.

Storms of the cold weather period, 1881-82.—This period, like the two preceding cold weather periods, was very free from cold weather storms. Two disturbances during this period were of sufficient importance to be classed as storms according to the definition in the introductory chapter. These were the storm of the 10th to the 13th January and the storm of the 10th to the 16th February. The following gives a history of these two disturbances, the tracks of which are laid down in chart 4, Plate LVI.

(I.) Storm of the 10th to the 13th January 1882.—This was a small storm which entered Sind from Baluchistan. The following gives a summary of the barometric changes of the 8th and 9th :—

DISTRICT.	CHANGE OF PRESSURE DURING 24 HOURS PRECEDING 10 A.M. OF THE			CLOUD AMOUNT AT 10 A.M. OF		
	8th.	9th.	10th.	8th.	9th.	10th.
Punjab	+·051	—·040	—·012	3·8	4·0	10·0
Sind	?	—·023	—·070	3·5	3·0	9·0
Rajputana	+·029	—·064	—·051	1·5	2·0	8·0
North-Western Provinces	+·076	—·041	—·007	0·5	0·7	6·3
Guzerat	? •	—·045	—·072	3·0	8·0	8·0
Central Provinces	+·026	—·044	—·033	0	1·5	3·0
Bengal	+·032	—·034	—·003	0·8	0·2	1·0
Bombay	+·027	—·022	—·053	0·8	0·3	1·5
Madras	+·049	—·028	—·011	5·3	2·6	1·6
Burma	+·028	—·006	+·013	0·3	2·7	4·7

The preceding table indicates that the barometer was falling briskly in North-Western India on the 8th and 9th. This was the first indication of the appearance or

formation of the depression. The following gives 10 A.M. data for the depression area :—

STATION.	PRESSURE.			WIND.		Cloud amount at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction at 10 A.M.	Miles per hour past 24 hours.	
Quetta	"	—'096	—'037	Calm	2	10
Jacobabad	30'094	—'070	—'032	NE	2	9
Kurrachee	30'022	—'056	—'053	ESE	?	10
Deesa	30'004	—'072	—'050	N	10	8
Bickaneer	30'011	—'061	?	S	2	10

The observations apparently indicate the approach of a shallow depression from the west to Sind and Rajputana, but the barometric and wind data give somewhat conflicting evidence. Winds were light and below their average strength generally. Skies were overcast in Sind, Rajputana, the Punjab and the greater part of the North-Western Provinces.

Temperature as usual before the approach of these storms was excessive. This feature was most marked at the following stations in front of the storm :—

STATION.	VARIATION OF			Change in previous 24 hours.
	Maximum temperature.	Minimum temperature.	Mean temperature.	
Deesa	+6'3	+16'1	+11'2	+3'5
Ajmere	+5'9	+12'4	+9'2	+6'7
Sirsa	+3'4	+10'5	+7'0	+8'5
Bickaneer	?	?	?	+3'0

Isolated showers had occurred at Quetta and in Sind and Rajputana during the previous 24 hours, but the amounts were small.

11th January.—The barometric changes of the previous 24 hours were mainly due to the transfer of this depression into Central Rajputana. The following observations define its position at 10 A.M. of the 11th :—

STATION.	PRESSURE.			WIND.		Cloud amount at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction at 10 A.M.	Average hourly velocity previous 24 hours.	
Jeypore	30'015	—'095	—'104	E	9	5
Ajmere	30'000	—'067	—'080	Calm	2	10
Bickaneer	29'923	—'088	?	Calm	3	10
Deesa	30'016	+ '012	—'045	WSW	10	10

The depression was hence small in amount and the winds in the central area light. In the Gangetic plain easterly winds prevailed and over Bengal northerly to north-easterly winds.

General light to moderate rain had been received to the north of the depression in the Punjab, where there was a slight tendency to the establishment of a subsidiary depression.

A very rapid reduction of temperature had occurred in Sind and Rajputana, e.g. :—

STATION.	VARIATION FROM NORMAL OF			Change in previous 24 hours.
	Maximum temperature.	Minimum temperature.	Mean temperature.	
Kurrachee	— 4°3	+ 0°2	— 2°1	— 4°9
Deesa	— 3°9	+ 0°5	+ 2°8	— 9°0
Mooltan	— 11°2	+ 7°7	— 1°8	— 4°9
Ajmere	— 9°2	+ 9°2	0	— 9°0

12th January.—A general increase of pressure had occurred during the previous 24 hours. It was greatest in amount in Rajputana, in which it varied from one to two-tenths. The depression had hence almost entirely filled up. So far as can be judged, it was breaking up in the neighbourhood of the hills.

Skies were rapidly clearing over the whole of Upper India, and fine clear weather speedily followed the re-establishment of high pressure over Northern India.

The storm was hence throughout of very slight intensity. It entered Sind from Baluchistan, and marched eastwards through Rajputana, but filled up as it approached the Himalayas of the North-Western Provinces. It gave moderate and fairly general rainfall to the whole of Upper India, including the Punjab, Sind, Rajputana and the North-Western Provinces.

The following gives a brief statement of the rainfall during the storm :—

DISTRICT.	AVERAGE RAINFALL OF THE		Total of storm period.
	11th.	12th.	
Sind	Inch. Nil	Inch. Nil	Inches. Nil
Punjab	0°80	0°53	1°33
Rajputana	0°30	0°1	0°42
North-Western Provinces	0°04	0°32	0°36
Oudh	Nil	0°04	0°04

The following gives examples of the large reduction of temperature accompanying the passage of the cool wave on the 12th and 13th across Northern India :—

DATE.	STATION.	VARIATION FROM NORMAL OF			Change in previous 24 hours.
		Maximum temperature.	Minimum temperature.	Mean temperature.	
12th	Deesa	— 13°8	— 3°9	— 8°9	— 11°7
	Bickaneer	?	?	?	— 9°0
	Ajmere	— 16°6	+ 2°6	— 7°0	— 7°1
13th	Lahore	— 6°4	+ 1°4	— 2°5	— 2°8
	Delhi	— 9°2	— 3°2	— 6°2	— 8°2
	Roorkee	— 7°3	— 0°2	— 3°8	— 4°6
	Agra	— 6°2	— 1°1	— 3°7	— 9°0

These conditions of high pressure and fine clear weather lasted steadily until the 21st, when pressure gave way, skies became cloudy, and weather slightly unsettled. This continued until the end of the month. During this interval no marked depression however formed or appeared in Upper India.

Pressure decreased over the whole of India on the 28th and 29th, and on the morning of the 30th a shallow depression was established on the Central India plateau. It moved eastwards during the next 24 hours, and the centre was near Sutna at 10 A.M. of the 31st. Light showers had fallen on the hills and in the East Punjab.

A rapid increase of pressure in North-Western India (exceeding two-tenths of an inch at many stations) accompanied the advance of the depression into Bengal. The centre at 10 A.M. of the 1st of February was in Lat. 24° N. and Long. 88° E. Light local showers had fallen in Rajputana and the western districts of the North-Western Provinces. It passed through East Bengal into Upper Burma on the morning of the 2nd. Assam and Cachar had received light showers during the previous day. Fine clear weather was re-established in Northern India on the 1st and 2nd.

The disturbance was a small one and is, hence, not included in the list of storms. It almost certainly originated in Central India and drifted eastwards. It gave very little rain. The East Punjab, Rajputana and the western districts of the North-Western Provinces received light local showers on the 30th and 31st and Assam on the 2nd February.

(II.) *Storm of the 10th to the 16th February 1882.*—Well-marked anti-cyclonic conditions obtained in North-Western India at the commencement of the month, but there was a tendency to the prevalence of local low pressure over the Western Himalayan area. No important change occurred until the 8th, when the weather also became slightly unsettled at Quetta.

The following table gives the barometric changes in different parts of India of the 7th and 8th February (*i.e.*, of the 24 hours preceding 10 A.M. of the 8th and of the 9th):—

District.	CHANGES OF PRESSURE ON		CLOUD AMOUNT AT 10 A.M. OF	
	8th.	9th.	8th.	9th.
Punjab	"	"		
	—'002	—'068	3'6	4'8
Sind	—'018	+ '040	5'5	5'5
Rajputana	—'010	—'043	0'5	2'0
North-Western Provinces	—'010	—'060	3'0	2'3
Guzerat	—'031	+ '020	0	0
Central Provinces	—'010	—'031	0	0
Bengal	—'018	—'034	2'3	1'3
Bombay	—'019	+ '007	0	0
Madras	+ '005	—'002	2'8	1'8
Burma	—'020	—'027	4'0	2'3

On the morning of the 8th an area of high pressure stretched from the West Punjab frontier to Central Bihar. On the 9th the pressure distribution was complicated, pressure being highest in the Madras coast districts, Upper Assam and the North Punjab,

in all of which areas it slightly exceeded 30·10 inches. A very shallow depression covered Rajputana and the South-East Punjab.

So far as the observations indicate, the low pressure area formed in North-Western India and did not pass into it from Baluchistan. The following table, giving the barometric changes at eight representative stations from the 6th to the 10th, appears to be conclusive on this point:—

STATION.	PRESSURE CHANGES ON				
	6th.	7th.	8th.	9th.	10th.
Quetta	—·031	—·060	—·066	—·015	—·108
Murreo	+·026	—·018	—·017	—·002	—·149
Jacobabad	—·081	—·044	0	+·064	—·140
Deesa	—·047	—·025	—·042	+·018	—·039
Mooltan	—·047	—·019	—·024	—·039	—·110
Lahore	—·052	—·078	—·019	—·092	—·072
Jeypore	—·011	—·055	—·002	—·045	—·113
Agra	+·005	—·066	—·020	—·062	—·117

The following observations of the 9th define the area in which the depression was forming:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Lahore	29·993	—·092	—·036	N	5	0
Mooltan	30·024	—·039	—·022	NNW	4	10
Bickaneer	29·953	—·090	?	SSW	2	8
Jeypore	30·017	—·045	—·019	SW	4	3
Ludhiana	30·002	—·096	—·029	Calm	2	10

These observations show clearly the tendency to the formation of a shallow depression, in Rajputana and the neighbouring districts of the Punjab.

10th February.—Pressure decreased during the 24 hours preceding 10 A.M. of the 10th over the whole of India, but most rapidly over the Punjab, Upper Sind and Rajputana. The depression was hence more marked than on the 9th. The following observations show its position at 10 A.M. at that date:—

STATION.	PRESSURE.			WIND.		Cloud amount at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction at 10 A.M.	Average hourly velocity previous 24 hours.	
Lahore	29·871	—·072	—·183	SE	5	0
Mooltan	29·897	—·110	—·171	NW	4	8
Jeypore	29·904	—·113	—·130	NNW	3	8
Bickaneer	29·877	—·078	?	WNE	3	10
Rawalpindi	29·868	—·168	—·178	SE	3	8
Peshawar	29·914	—·181	—·154	Calm	1	0
Murree	?	—·149	—·086	SW	19	10
Quetta	?	—·108	—·175	SSW	8	5

These observations show in the first place that the primary depression had intensified and was moving eastwards. The large fall in the North Punjab and at Murree indicates that there was already a strong tendency to the formation of a subsidiary depression in the Punjab.

Winds were light in Upper India but had increased rapidly in force at Murree and to a less extent at Quetta. Skies were overcast in the Punjab Himalayas, partially clouded in the Punjab, and clear over the remainder of Northern and Central India.

The most remarkable feature of the depression was the excessive temperature in the area of depression. The following gives data :—

STATION.	VARIATION FROM NORMAL OF			Change in 24 hours preceding 10 A.M. of the 10th.
	Maximum temperature of previous 24 hours.	Minimum temperature of previous 24 hours.	Mean temperature of day.	
Agra	+12'5	+12'7	+12'6	+7'9
Delhi	+13'2	+ 8'6	+10'9	+3'0
Lahore	+ 5'6	+12'8	+ 9'2	+6'5
Deesa	+10'6	+ 6'8	+ 8'7	+0'1
Ajmere	+12'6	+13'5	+13'1	+5'3

Hence a very rapid rise of temperature had occurred in the area of disturbance whilst the depression was developing, and both the day and night temperatures of the preceding 24 hours were very largely above the average.

On the other hand, at the hill stations and to the west of the depression temperature was decreasing as is shown by the following :—

STATION.	VARIATION FROM NORMAL OF			Change in 24 hours preceding 10 A.M. of the 10th.
	Maximum temperature.	Minimum temperature.	Mean temperature.	
Quetta	—0'4	+10'8	+5'2	—3'2
Murree	—0'8	+ 2'2	+0'7	—1'3
Jacobabad	—1'3	+ 5'5	+2'1	—2'2
Mooltan	—4'4	+12'4	+4'0	—3'2

Rain had fallen in the hills and the West and North Punjab, but the amounts were generally small.

11th February.—The barometric changes of the previous 24 hours were remarkable, and can only be explained by assuming that the primary depression in North and Central Rajputana on the 10th was moving eastwards, and that a deep secondary depression had formed in the North Punjab.

The following gives the average barometric changes in different parts of India and the average cloud amount at 10 A.M. :—

DISTRICT.	Mean barometric change in past 24 hours.	Average amount of cloud.
Punjab	—'215	5'2
Sind	—'109	0
Rajputana	—'110	4'0
North-Western Provinces	—'177	4'3
Guzerat	—'126	5'0
Central India	—'160	3'0
Central Provinces	—'120	0
Bengal and Assam	—'080	5'6
Bombay	—'062	0
Madras	—'078	1'0
Burma	—'024	1'0

The large fall in the Punjab and North-Western Provinces as compared with Sind and Rajputana is only explicable on the assumption stated above. The following gives data defining the central area of the secondary depression in the North Punjab :—

STATION.	PRESSURE.			WIND.		Cloud amount at 10 A.M.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from mean of day.	Direction at 10 A.M.	Average hourly velocity previous 24 hours.	
Murree	? "	—'274	—'357	Calm	7	10
Peshawar	29'603	—'311	—'445	WNW	2	8
Rawalpindi	'670	—'234	—'370	Calm	1	0
Dera Ismail Khan	'707	—'234	—'359	SW	1	0

The air movement (even at the elevation of Murree) was hence remarkably feeble, thus suggesting that it was almost entirely ascensional in this part of the Punjab. Skies were clouded in the hills, but had cleared in the West Punjab and Rajputana, and were partially clouded in the plains from Rawalpindi to Lucknow.

The position of the primary depression is defined by the following stations :—

STATION.	PRESSURE.			WIND.		Cloud amount at 10 A.M.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from mean of day.	Direction at 10 A.M.	Average hourly velocity previous 24 hours.	
Sutna	29'748	—'183	—'243	W	5	0
Nowgong	'732	—'158	—'274	W	3	6
Agra	'717	—'169	—'316	E	6	1
Allahabad	'738	—'196	—'282	SE	4	0
Benâres	'758	—'189	—'247	E	3	7

The fall in North-Western India was hence due to two actions, *vis.* the advance of the primary depression and the development of the secondary depression.

Allowing for the fall due to the secondary depression, the following gives the calculated barometric variation from the normal due to the advance of the primary depression into Central India and the eastern districts of the North-Western Provinces :—

STATION.	Barometric change due to eastward advance of the primary depression.
Agra	—'049
Nowgong	—'048
Jhansi	—'060
Sutna	—'088
Allahabad	—'096
Benares	—'089

These figures hence appear to establish that the centre of the primary depression was near Allahabad.

Skies were either very lightly clouded or clear in this area in which there was a fairly well-marked moderate independent cyclonic circulation.

The following gives temperature data for the previous 24 hours of four stations in the primary area of depression :—

STATION.	VARIATION FROM NORMAL OF			Change in past 24 hours.
	Maximum temperature.	Minimum temperature.	Mean temperature	
Agra	+12'4	+12'8	+12'6	0
Lucknow	+ 8'6	+16'5	+12'6	+7'1
Allahabad	+10'7	+12'2	+11'5	+6'7
Ajmere	+ 5'1	+17'6	+11'4	—1'8

Hence a rapid increase of temperature had occurred during the previous 24 hours to the east of the central primary depression, while (as shown by the Ajmere temperature data) it was decreasing to the west.

Temperature was falling at the hill stations, on the North-West frontier and in the Punjab. The following gives examples :—

STATION.	VARIATION OF			Change in past 24 hours.
	Maximum temperature.	Minimum temperature.	Mean temperature.	
Murree	0 2'2	+0'5	—0'9	—1'7
Kurrachee	+1'7	+8'0	+4'9	—3'9
Lahore	+02	+8'4	+4'3	—4'7

Moderate rain had fallen in the Punjab and western districts of the North-Western Provinces. The following gives a statement of the rainfall of the preceding 24 hours :—

AREA.	Total number of stations in district.	Number of stations at which rain fell.	Average rainfall.	Largest amount in area.
			Inches.	Inches.
West Punjab	11	5	0'11	0'50
East "	13	12	0'54	1'25
South "	6	5	0'28	0'55
Rajputana	21	Nil	Nil	Nil
Central India	18	Nil	Nil	Nil
North-Western Provinces, West . .	14	11	0'34	1'10
" " East	21	2	0'01	0'20
Oudh	12	1	0'01	0'10
Bengal	29	21	0'23	1'32
Bihar	12	8	0'08	0'30
Chota Nagpur	6	1	0'01	0'08
North-Western Provinces Hills . .	5	5	1'00	1'86
Punjab Hills	5	4	0'57	1'72

12th February.—A very rapid increase of pressure in Upper India filled up the secondary depression in that area on the 11th. The primary depression had advanced into West Bengal. Its position is given by the following data :—

STATION.	PRESSURE.			WIND.		Cloud amount at 10 A.M.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from mean of day.	Direction at 10 A.M.	Miles per hour past 24 hours.	
Calcutta	29'801	—'054	—'194	SW	11	7
Berhampore	'773	—'130	—'235	SW	4	10
Purnea	'815	—'091	—'174	NE	3	7
Patna	'825	—'002	—'178	E	9	6
Burdwan	'778	—'087	—'233	SW	7	4
Jessore	'780	—'124	—'203	WSW	2	6

The centre of this depression was hence in about Lat. $24\frac{1}{2}^{\circ}$ or 25° N. and Long. $87\frac{1}{2}^{\circ}$ E.

The barometric rise in the Punjab ranged from '11 inch at Delhi to '30 inch at Peshawar.

Skies had clouded over in North-Eastern India, and showers had fallen in Bihar, Bengal and Assam. Bihar had received an average of '21 inch, Bengal of '39 inch and Assam of 1'25 inches during the previous 24 hours. Skies had cleared completely in the

Punjab and North-Western Provinces, and a cool dry wave was advancing across Northern India. The following data illustrate the change which had occurred:—

STATION.	VARIATION FROM NORMAL OF			Change in preceding 24 hours.
	Maximum temperature.	Minimum temperature.	Mean temperature.	
	o	o	o	o
Lahore	—13'2	+0'3	—6'5	—10'2
Roorkee	—4'5	+2'3	—1'1	—9'4
Agra	+3'1	+1'0	+2'1	—10'2
Allahabad	+9'8	+5'7	+7'8	—3'4

13th February.—The barometer rose slowly in North-Western India during the previous 24 hours and briskly to rapidly in Bengal. The depression which was in that area on the previous day had either filled up or passed into Burma, but in the absence of observations in Upper Burma it is not possible to decide. The great majority of stations in Bengal reported calms at 10 A.M. The cool wave in the rear of the depression had now extended across the North-West Provinces into Bihar and Bengal. The following gives temperature data illustrating this advance:—

STATION.	VARIATION FROM NORMAL OF			Change in preceding 24 hours.
	Maximum temperature.	Minimum temperature.	Mean temperature.	
	o	o	o	o
Lucknow	+5'8	—5'6	+0'1	—4'7
Allahabad	+2'7	—2'6	+0'1	—7'4
Patna	—1'9	+2'4	+0'3	—7'5
Burdwan	+4'5	+6'0	+5'3	—5'6

This diminution of temperature accompanied the advance of westerly winds down the Gangetic plain. This also caused a very rapid reduction in the amount of aqueous vapour, as, for example:—

STATION.	AQUEOUS VAPOUR PRESSURE AT 10 A.M. OF		Change in past 24 hours.
	12th.	13th.	
	"	"	"
Agra	'485	'222	—'263
Lucknow	'444	'224	—'220
Allahabad	'393	'238	—'155

The observations of this day give the first indications of the formation of another

shallow depression in Rajputana. The following data fix the position of this incipient depression :—

STATION.	PRESSURE.			WIND.		Cloud amount.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from mean of day.	Direction at 10 A.M.	Average hourly velocity of past 24 hours.	
Ajmete	29'859	—'012	—'146	S	2	0
Bickaneer	29'835	—'012	?	ESE	3	3
Mooltan	29'920	+ '035	—'143	NE	2	4
Jacobabad	29'894	—'026	—'163	NE	6	0
Deesa	29'918	+ '011	—'069	WSW	7	4

The cyclonic circulation, although feeble, was distinctly marked. Skies were clouding over in North-Western India, as is shown by the following data :—

DISTRICT.	Cloud amount at 10 A.M. of 13th.	Cloud amount at 10 A.M. of 12th.
Pupjab	56	20
Sind	20	10
Rajputana	10	10

14th February.—The barometric changes of the previous 24 hours were slight. No change of importance had occurred in the area of depression in Rajputana. The following gives data, showing that it was unaltered in character and was moving slowly eastwards :—

STATION.	PRESSURE.			WIND.		Cloud amount at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from mean of day.	Direction at 10 A.M.	Average hourly velocity previous 24 hours.	
Ajmere	29'855	—'004	—'147	S	5	1
Bickaneer	'852	—'013	?	E	5	4
Mooltan	'941	+ '021	—'115	NE	2	4
Jacobabad	'916	+ '022	—'137	NNE	6	0
Deesa	'888	—'030	—'099	WSW	13	7
Quetta	?	+ '024	—'128	WNW	4	1

These observations establish that there was a feeble cyclonic circulation over the area of depression. Light showers occurred along the foot of the hills and in the hill districts.

15th February.—The barometric changes were again small, the only important ones being a moderate fall in East Rajputana due to the eastward movement of the depression. The following observations define the position of the depression at 10 A.M. :—

STATION.	PRESSURE.			WIND.		Cloud amount, 10 A.M.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from mean of day.	Direction at 10 A.M.	Average hourly velocity previous 24 hours.	
Agra	29'828	—'078	—'195	SE	5	8
Delhi	29'860	—'056	—'161	NE	5	2
Jeypore	29'818	—'057	—'205	W	5	2

The depression had increased slightly and was more plainly marked, but was still feeble and the cyclonic circulation of slight intensity. Light showers had fallen at Chakrata, Roorkee and Delhi, but the rainfall was insignificant in amount.

The disturbance filled up during the next 24 hours, anti-cyclonic conditions being established on the 17th by a rapid rise of pressure in Punjab, Sind and Rajputana on the 16th, ranging from one to two-tenths in amount.

This storm was hence throughout of very little importance, and is given chiefly as an undoubted example of a depression which formed in North-Western India and which did not pass into it from Baluchistan, etc. It was throughout a shallow depression, and gave very little rain. Although very feeble, the cyclonic circulation was on the whole more regularly developed than in the more intense cyclonic storms of the period.

The months of March and April were much drier than usual and very free from rain-giving depressions in Upper India. The barometer fell very rapidly on the 27th March in Baluchistan and Upper India, and a deep depression appeared in the Indus Valley on the morning of the 27th. The following observations define its character and position at 10 A.M. of that date :—

STATION.	PRESSURE.			WIND.		Cloud amount at 10 A.M.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Quetta	?	—'104	—'086	NNW	7	10
Jacobabad	29'568	—'200	—'345	N	2	7
Mooltan	29'539	—'182	—'346	NW	2	0
Bickaneer	29'709	—'066	?	SW	8	0
Hyderabad	29'835	—'023	—'022	SW	15	0

Skies were partially clouded in Sind and the Punjab, and light showers had fallen at Quetta and Peshawar. The depression advanced eastwards to the foot of the Himalayas

during the next 24 hours. The following observations show its position at 10 A.M. of the 28th:—

STATION.	PRESSURE.			WIND.		Cloud amount at 10 A.M.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Jacobabad	29.792	+ .224	— .040	NE	?	0
Mooltan	29.832	+ .243	— .013	NE	0	2
Bickaneer	29.780	+ .075	?	WSW	9	?
Lahore	29.765	+ .112	— .135	NW	6	8
Ludhiana	29.749	+ .031	— .062	SSE	4	0
Roorkee	29.794	— .004	— .098	SE	6	0
Delhi	29.745	+ .023	— .146	SE	3	0

A few light showers had fallen in the North Punjab, during the previous 24 hours. Pressure increased rapidly in Upper India during the next 24 hours, and the depression disappeared before the morning of the 29th. It belongs rather to the category of hot weather disturbances and depressions in Upper India, and is not included in the list of cold weather storms.

The cold weather of 1881-82 was hence unusually free from severe cold-weather storms. A noteworthy feature of the period was the tendency to the formation and appearance of depressions in Rajputana. Only one storm of importance passed across Northern India. If it was the continuation of a disturbance which advanced across Baluchistan into Sind (of which there is no clear indication in the observations of the period) it combined with a pre-existing depression in Rajputana. This disturbance gave rise to a considerable secondary depression in the Punjab.

1882-83.

Chief abnormal features of the meteorology of India in 1882.—The cold weather of 1881-82 was unusually dry and free from storms. During this period the mean pressure over the whole of India was generally in defect by small amounts. The pressure anomalies were small, and varied from month to month, thus indicating the absence of any large and persistent abnormal pressure conditions during this period. The month of March was unusually dry. April was more disturbed than usual, more especially in the Punjab and Bengal. The weather conditions in May were practically normal. There was during the greater part of the hot weather period a slight excess of pressure relative to the mean state in North-Eastern India, greatest in Bihar and a small deficiency in North-Western India and the Peninsula. The south-west monsoon rains set in somewhat earlier than usual. They commenced on the Bombay coast about the 2nd June, and in Bengal about the 11th June. In June the rainfall was generally above the average. The Bengal monsoon was weak in July and the Bombay current strong. Hence the rainfall was in excess except in North-Eastern India where there was a large deficiency. The conditions were reversed in August, and a longish break, lasting from the 5th to the 20th, obtained in North-Western India. North-Eastern India received larger amounts than

usual in August, but there was a general deficiency in North-Western and Central India and Bombay. The rains ceased in Upper India on the 15th September, and were on the whole abundant in that month, except in East Bengal, where they were largely in defect. Bengal received heavy rain in October. The same conditions which gave this heavy rainfall to Bengal deprived Madras of rainfall. The retreating south-west monsoon did not commence to give general rain in the Carnatic until the end of the month. It gave a heavy downpour over the greater part of the Peninsula in November, but ceased earlier than usual in December. The rainfall of that month was small in amount. The following gives a summary of the rainfall data of the south-west monsoon of 1882:—

DISTRICT.	VARIATION FROM NORMAL.	
	Ordinary south-west monsoon rainfall, June to Sept., 1882.	Retreating south-west monsoon rainfall Oct. to Dec., 1882.
Punjab	inches, +1'48	inches, —1'53
Rajputana	+2'40	—0'73
North-Western Provinces and Oudh	—1'39	—0'35
Bengal and Bihar	—5'82	+2'14
Assam	—8'72	+7'54
Central Provinces	+5'74	—0'02
Berar	+1'02	—1'16
Central India	+5'36	+1'41
Bombay	+9'10	—1'03
Madras	+2'57	+3'45
Burma	+10'92	—0'37

The following are the chief antecedent meteorological conditions which may have influenced the rainfall of the cold weather season of 1882-83 in Upper India:—

- 1st.—The south-west monsoon rains were on the whole above the average over nearly the whole of India. They terminated somewhat earlier than usual in Upper India, but were prolonged to the end of October in North-Eastern India.
- 2nd.—The north-east monsoon rains in Madras commenced late in October and terminated early in December. Hence, although they were very abundant in November, they were on the average of the whole period above the normal to a slight extent.
- 3rd.—The pressure conditions varied considerably from month to month during the period October 1882 to March 1883, and the anomalies were also in several cases large. There was, however, no feature in the pressure conditions as indicated by the anomalies constant throughout the season.
- 4th.—The pressure variations at the hill stations were somewhat inconstant in character. Pressure was relatively in excess, generally by small amounts at the hill stations, and more especially at Leh, from September to

December. It was in moderate defect from January to March, the deficiency being large only at Leh. The following table gives data :—

MONTH.	VERTICAL PRESSURE ANOMALIES.			
	Leh <i>minus</i> Lahore.	Murree <i>minus</i> Peshawar.	Chakrata <i>minus</i> Roorkee.	Ranikhet <i>minus</i> Bareilly.
September 1882	—'023	—'012	—'018	—'014
October "	+ '015	+ '047	+ '009	+ '011
November "	+ '003	+ '035	—'024	—'023
December "	+ '052	+ '061	+ '024	+ '005
January 1883	—'056	—'020	—'027	—'040
February "	—'063	+ '005	—'016	+ '029
March "	—'057	+ '002	—'029	+ '023

Chief features of the meteorology of the cold weather period, 1882-83.—

The following extract from the Annual Report for 1883 gives a sketch of the chief features of the meteorology of the cold weather season of 1882-83:—

"The year 1883 opened with rainless but warm and cloudy weather in Northern India and a frequent prevalence of southerly winds in Central India and the North-West, which resulted in light rain on the 9th and 10th of January, and between the 24th and 28th in a much heavier fall, accompanied with thick snow on the North-Western Himalaya down to a level much below 2,000 feet. This fall brought down the temperature to such a degree that the whole of February was unusually cool, and in a large part of Northern India lower temperatures were recorded than any that had occurred earlier in the season. A few light falls of snow took place on the Himalaya during February, but on the plains there was little or no rain, and the greater part of Northern and Western India was swept by steady west and north-west winds, dry and cool, which are indeed the characteristic winds of the cold weather. In the Peninsula, save in the Konkan, the depression of temperature was not felt, and south-easterly winds prevailed with a somewhat higher temperature and damper atmosphere than usual in parts of Orissa, the Central Provinces and the Deccan.

"Showery weather set in again throughout Northern India in the beginning of March and lasted for about 12 days; and although there was little rain subsequently on the plains in the latter part of the month, some further falls of snow and rain took place on the Himalaya, which, like the previous falls, were chiefly restricted to the outer ranges. In consequence of this rain the weather remained remarkably cool through the greater part of March; but after the rain had ceased on the plains, dry winds set in which lasted throughout April."

The following table gives the variation of the rainfall from the normal throughout the cold weather of 1882-83 in Northern India :—

PROVINCE OR AREA.	Variation from normal of average actual rainfall of period 1st December 1882 to 31st March 1883.	Percentage variation.
	Inches.	
Punjab	—0'99	—27
Rajputana	—0'06	—8
Central India	+0'05	+5
North-Western Provinces and Oudh	+1'52	+72
Bengal	—0'01	0
Assam	—2'09	—34
Central Provinces	—0'64	—40
Bihar	—1'09	—91

The rainfall of the cold weather period of 1882-83 was hence somewhat irregularly distributed. It was below the normal of the period over the greater part of Northern and Central India, the deficiency being greatest in Assam and the Punjab. It was locally in considerable excess in the North-Western Provinces due to the unusual distribution of rainfall accompanying the one important storm of the season.

Storms of the cold weather period, 1882-83.—Several depressions appeared in North-Western India during this period, but only one was of sufficient intensity and duration to be classed as a cold weather storm. The following gives an account of the one important disturbance of this period, *viz.* the storm of the 23rd to the 29th January, the track of which is given in chart 1, Plate LVII.

A very slight disturbance affected Northern India on the 9th, 10th and 11th of January. Pressure was at the time considerably above the normal, exceeding for example 30·3" in the Punjab on the 10th. The disturbance gave thundershowers to the North-Western Provinces and Bihar on the 9th and 10th, and Assam on the 10th and 11th. Weather was fine with high pressure, westerly winds and clear skies in Northern India until the 22nd, when the most influential cold weather disturbance of the season was formed.

(I) Disturbance of the 23rd to the 29th January 1883.—This storm passed into India from Baluchistan. The primary depression advanced across Northern India. It gave rise to a deep secondary depression in the Punjab for a short period. The barometer fell over nearly the whole Indian region for upwards of two days before the storm approached Upper Sind.

The following gives the average barometric changes for the 24 hours preceding 10 A.M. of the 22nd and 23rd :—

DISTRICT.	Mean change of pressure in 24 hours preceding 10 A.M. of	
	22nd.	23rd.
Punjab	—·006	—·091
Rajputana	—·028	—·038
Sind	+·032	—·036
North-Western Provinces	—·025	—·086
Central Provinces	+·015	—·089
Central India	+·026	—·094
Bengal	—·014	—·057
Burma	—·004	—·053
Madras	+·012	—·035
Bombay	+·014	—·023

The storm was passing through Baluchistan on the 23rd, but was on that day apparently of small intensity and extent.

The following gives data :—

STATION.	PRESSURE.			WIND.		Cloud amount at 10 A.M.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Quetta	?	—'086	—'087	SSW	1	6
Kurrachee	30'071	—'019	—'018	SE	7	0
Jacobabad	30'015	—'051	—'039	SE	1	2
Mooltan	30'018	—'076	—'059	Calm	1	0

Winds were very light and unsteady in Northern and Central India, and many stations reported calms. Temperature (both day and night) was above the normal. Skies were clear or lightly clouded in Sind, the Punjab, Rajputana and Gangetic plain, but were clouded at the hill stations in the Punjab and at Quetta. A few light showers had been received in the Central Provinces during the previous 24 hours.

24th January.—The 10 A.M. observations show that the depression had advanced from Baluchistan into Upper Sind, and that the centre was near Jacobabad. The following data define its position :—

STATION.	PRESSURE.			WIND.		Cloud amount at 10 A.M.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Quetta	?	—'112	—'187	WNW	5	10
Kurrachee	29'849	—'222	?	SSE	9	9
Hyderabad	29'843	—'190	—'223	S	5	9
Jacobabad	29'799	—'216	—'247	SE	2	6
Mooltan	29'877	—'141	—'192	NE	2	10

The centre of the depression was in Lat. 28° N. and Long. 68° E., and the depression at the centre was at least a quarter of an inch.

The barometric observations also show that a secondary depression was commencing to form in the North Punjab, *e.g.* :—

STATION.	PRESSURE.			WIND.		Cloud amount at 10 A.M.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Murree	?	—'139	—'169	ESE	13	10
Peshawar	29'868	—'138	—'216	Calm	2	10
Dera Ismail Khan	29'904	—'137	—'173	ESE	1	9

The wind was increasing very rapidly in force at Murree, and the fall of the barometer at that station and Peshawar was as large as at Mooltan.

Skies were overcast in the Punjab and Rajputana, but were clear in the Gangetic VOL. IV.

plain and Bengal. A moderate increase of temperature and also of aqueous vapour had occurred over the whole of North-Western India.

Rain had fallen generally during the previous 24 hours in the Punjab and some light showers in Sind, Rajputana and Central India. Four stations in the Punjab reported rainfalls slightly exceeding one inch.

25th January.—The primary depression was obscured by the rapid development of the secondary depression in the Punjab. The isobars however indicate that it was passing through Central Rajputana and that the centre was probably near Sambhar. The chart of this day is given on Plate LXIII to show the peculiar features of the distribution of pressure as indicated by the isobars due to the combination of the two depressions. The following gives data for stations nearest to the centre of the primary depression:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Ajmere	29'715	—'178	—'335	SW	4	5
Sambhar	'708	—'176	—'308	SE	17	7
Jeypore	'733	—'157	—'307	ESE	8	10

A very rapid fall had occurred over the Punjab, and a deep depression, the centre of which was a little to the south of Lahore, had now formed. The following gives data:—

STATION.	PRESSURE			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity, previous 24 hours.	
Murree	P	—'158	—'318	SE	24	10
Simla	P	—'260	—'228	S	3	10
Lahore	29'627	—'324	—'421	ESE	6	6
Ludhiana	29'684	—'201	—'414	SE	3	9
Sialkot	29'708	—'224	—'333	E	6	10
Mooltan	29'664	—'213	—'397	NW	4	9
Bickaneer	29'634	—'233	P	SW	4	10

A strongish and well defined cyclonic circulation hence prevailed over the area of depression. Winds had shifted to east in Bengal and Bihar, but were light. A very rapid decrease had taken place in the day temperature in Upper India, and the setting-in of north-west winds in Sind had caused a large reduction in the amount of aqueous vapour present in the atmosphere in that area, *e.g.*

STATION.	AMOUNT OF AQUEOUS VAPOUR ON		
	24th.	25th.	Change in 24 hours preceding 10 A.M. of 25th.
Kurrachee	'568	'230	—'338
Jacobabad	'387	'310	—'077

Skies had cleared in Sind, but were overcast in the Punjab, the North-Western Provinces and North Rajputana.

Heavy rain had fallen during the previous 24 hours in the Punjab, the North-Western Provinces and Oudh, and showers in Rajputana and Central India.

The following gives the largest amounts:—

DISTRICT.	Station.	Amount of rainfall.
PUNJAB	Sialkot	Inches. 2'70
	Gujrat	2'70
	Gujranwala	2'30
NORTH-WESTERN PROVINCES	Naini Tal	5'80
	Chakrata	2'26

26th January.—The primary depression, as on the 26th, was obscured by the secondary depression in the Punjab. A marked southerly bend of the isobars (see chart of day, Plate LXIII) indicates that it was passing through Bundelkhand, and that the centre was probably near Sutna. The following gives data:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction. 10 A.M.	Average hourly velocity, previous 24 hours.	
Jubbulpore	29'864	+ '025	- '219	Calm	2	10
Sutna	29'840	- '030	- '247	S	13	7
Nowgong	29'859	+ '066	- '191	W	1	10
Allahabad	29'891	- '023	- '158	E	6	9
Lucknow	29'897	- '016	- '161	E	8	10

The barometer had commenced to rise in Upper India, and the secondary depression in that area was filling up rapidly. A shallow depression in which pressure was slightly below 29'80" now covered the Punjab.

The following gives 10 A.M. observations of stations in the secondary depression on this day:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction. 10 A.M.	Average hourly velocity, previous 24 hours.	
Murree	P	+ '048	- '268	SSE	6	10
Ludhiana	29'791	+ '107	- '307	ESE	5	5
Sirsa	29'792	+ '169	- '255	Calm	3	4
Lahore	29'791	+ '164	- '266	Calm	4	10
Sialkot	29'772	+ '064	- '267	ESE	7	2
Mooltan	29'777	+ '113	- '291	NE	2	10
Bickaneer	29'763	+ '122	P	SW	2	01

Winds were feebly cyclonic in this area, but the great decrease in the strength of the wind at Murree indicated that the disturbance was passing away very rapidly.

Temperature had decreased very considerably in North-Western India. The decrease was greatest at Deesa (-10.6°), Ajmere (-9.9°) and Roorkee (-9.1°). The air was generally somewhat drier.

A very large reduction in the amount of aqueous vapour was exhibited in Sind and West Rajputana:—

STATION.	AQUEOUS VAPOUR PRESSURE AT 10 A.M., ON		Change in 24 hours preceding 10 A.M. of 25th.
	25th.	25th.	
Kurrachee	'176	'230	—'054
Jacobabad	'187	'310	—'123
Deesa	'188	'517	—'329
Mount Abu	'109	'226	—'117

Skies were clearing in the Punjab, but were generally overcast in the North-Western Provinces and Bihar. Very heavy general rain had been received in Oudh and the North-Western Provinces, and numerous thundershowers in the Punjab, Rajputana and Central India. The following give a few of the more remarkable rainfalls of the previous 24 hours:—

DISTRICT.	Station.	Amount of rainfall.
NORTH-WESTERN PROVINCES	Roorkee	Inches. 4'00
	Fatehpur	3'02
	Nawabganj	4'37
OUDH	Kheri	4'00
	Lucknow	3'75
	Sitapur	3'28

The rainfall in Oudh during the previous 24 hours averaged $2\frac{1}{2}$ inches, and was hence as large in amount as accompanies the larger cyclonic storms in the temperate regions of the Northern Hemisphere.

27th January.—The primary depression had advanced into Bihar and Chota Nagpur, and the centre at 10 A.M. was near Gaya. The following observations define its position at that hour:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Berdwan	29.916	—'133	—'150	S	2	10
Patna	29.961	—'089	—'108	E	8	10
Gaya	29.962	—'039	—'118	N	3	10
Hazaribagh	29.971	—'003	—'073	NW	13	10

A further rapid increase of pressure had occurred in Upper India, ranging in amount from '10" to '25" and the secondary depression had filled up almost completely.

Winds were light over the whole of Northern India. A feeble cyclonic circulation obtained in Bihar, and southerly winds from the Bengal coast were feeding into the depression.

Skies had cleared in the Punjab, Rajputana and the North-Western Provinces, but were heavily clouded in Bihar and Bengal. A general reduction of temperature and of humidity had occurred over the whole of the North-Western Provinces, Central India and Rajputana, and was greatest in the North-Western Provinces.

Some light and scattered showers of little importance had been received in the Punjab, the North-Western Provinces and Central India during the previous 24 hours. Oudh, Bihar and West and North Bengal had obtained fairly general and moderate rain. Patna, Gaya, Arrah and Muzaffarpur received amounts slightly exceeding one inch, and Khatmandu in Nepal $2\frac{1}{2}$ inches.

28th January.—The primary depression was transferred into East Bengal, and its position at 10 A.M. of this day is shown by the following observations:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Berhampore	30°010	+°088	—°029	W	4	0
Jessore	30°016	+°054	—°012	NW	6	0
Dacca	29°994	+°061	—°047	WSW	18	8
Dhubri	30°011	+°042	—°011	Calm.	8	9

The depression was by no means well defined, as it was filling up rapidly, but the observations indicate that the centre was near Dacca.

A large increase of pressure had occurred in Upper India and finally re-established high pressure and anti-cyclonic conditions in that area. The rise in the Punjab ranged from '06" at Lahore and Delhi to '23" at Peshawar.

Westerly winds had set in over the Gangetic plain, but were as yet feeble. Skies were now clear over the whole of Northern and Central India, but were clouded in Bengal and Assam. Temperature was largely below the normal by amounts ranging from 4° to 9° in North-Western and Central India. A considerable reduction in the amount of aqueous vapour present in the air had occurred in Northern India from Bihar westwards.

Rain had fallen as local showers in Bengal and Assam, but the amounts were generally small, in no case exceeding one inch.

The depression either passed into Upper Burma or filled up during the day, as on the morning of the 29th normal anti-cyclonic conditions with fine clear weather obtained over the whole of Northern India.

The disturbance hence consisted of a primary depression which advanced along an east-by-south track from Baluchistan and Upper Sind to East Bengal or Upper Burma,

and of a stationary secondary depression in the Punjab. The following gives the position of the centre of the primary depression at 10 A.M. of each day from the 24th to 28th:—

DATE.	APPROXIMATE POSITION OF CENTRE.		Distance travelled in 24 hours.
	Lat. N.	Long. E.	
	°	°	Miles.
24th	28	68	...
25th	26½	74½	425
26th	25	80½	390
27th	24½	86	350
28th	24	91	300

The disturbance was chiefly remarkable for the very heavy rainfall it gave to the Punjab and the North-Western Provinces and Oudh and Bihar. The following gives comparative rainfall data of the storm period from the 24th to 28th:—

DISTRICT.	AVERAGE ACTUAL RAINFALL IN 24 HOURS PRECEDING 6 P.M. OF					Total during the period.
	24th.	25th.	26th.	27th.	28th.	
	Inch.	Inch.	Inch.	Inch.	Inch.	Inches.
Punjab	0·40	1·14	0·31	0·09	0·08	2·02
North-Western Provinces	0·01	0·43	1·60	0·45	<i>Nil.</i>	2·49
Oudh	0·08	0·57	2·60	0·23	<i>Nil.</i>	3·48
Rajputana	0·07	0·30	0·13	<i>Nil.</i>	<i>Nil.</i>	0·50
Sind	0·25	0·07	<i>Nil.</i>	<i>Nil.</i>	<i>Nil.</i>	0·32
Central India	0·03	0·22	0·38	0·09	<i>Nil.</i>	0·72
Bihar	0·02	0·01	0·32	0·76	0·01	1·12
Chota Nagpur	0·04	0·05	0·01	0·32	<i>Nil.</i>	0·42
Bengal	0·08	<i>Nil.</i>	0·01	0·14	0·06	0·29
Assam	0·25	<i>Nil.</i>	<i>Nil.</i>	0·09	0·17	0·51
Central Provinces	0·01	0·09	0·18	0·05	<i>Nil.</i>	0·33
Berar	<i>Nil.</i>	<i>Nil.</i>	0·04	<i>Nil.</i>	<i>Nil.</i>	0·04

February was unusually free from disturbance. A small shallow depression crossed the South Punjab and North Rajputana from west to east on the 17th and 18th. It gave some showers on the 18th, chiefly to the North and East Punjab and the hill districts. A rapid increase of pressure, ranging from '1" at Delhi to '45" at Peshawar, accompanied its disappearance on the 19th. It was not, however, of sufficient intensity to be included in the list of storms.

A very shallow depression formed in Bengal on the 26th, similar in character to those which are formed in the hot weather. Thunderstorms with moderate rain occurred over the whole of Bengal on the 26th and 27th.

The first week of March was one of irregular disturbance, due apparently to rapidly increasing heat in Northern India. The barometric movements were extremely irregular over the whole of Northern and Central India, and local thunderstorms giving moderate showers occurred in the Punjab, the North-Western Provinces, Bengal and Assam. Some very heavy rainfalls were received during these thunderstorms in Bengal, *c. g.*—

						Inches.
2nd.	Tipperah	.	.	.	.	2.81
3rd.	Noakholly	.	.	.	.	5.28
4th.	Burdwan	.	.	.	.	2.50

Weather was unsettled with duststorms from the 11th to the 13th March in Upper India. This disturbance was of the usual hot-weather type, storms of which class usually form after a period of excessive temperature. They appear as irregularly diffused shallow depressions in some parts of Northern or Central India, and the barometric movements are during their existence very irregular in consequence of the occurrence of local thunderstorms, hailstorms and duststorms.

The cold weather of 1882-83 was hence very free from storms of the cold weather type and the season was hence drier than usual, more especially in the Punjab and adjacent mountain districts. Only one storm of importance occurred which traversed the whole breadth of Northern India at a rate of nearly 15 miles per hour. It gave rise to a deep secondary depression, the chief peculiarity of which was that it formed in the Central and South-East Punjab, and not in the North Punjab, as is almost invariably the rule. This storm gave an unusually heavy burst of rain to the North-Western Provinces, Oudh and Bihar.

1883-84.

Chief abnormal features of the meteorology of India in 1883.—As already stated, the month of January was a very disturbed month, with heavy snow in the hills. February, March and April were all drier than usual. May was on the other hand a stormy month, with heavy snow in the hills. The Bay of Bengal current set in about the usual time and the rainfall in June over the greater part of North-Eastern and Northern India was normal or above it. The Bombay current was late in being established and was very weak. A break commenced in Upper India on the 19th of July and extended over the whole of North-Western and Central India, which continued during the greater part of August. Hence the rainfall of these months was more or less in defect over the whole of India, except Burmah, Madras, Mysore and the Deccan.

The rains recommenced over Northern India in the third and fourth week of August. This final burst lasted in Upper India until the 15th of September, when the Bombay current rapidly retreated, and fine clear weather set in over Northern and Central India. The Bengal current continued to give moderate rain to North-Eastern India and Burmah in September and October, but the amounts received were generally considerably below the normal.

The rains ceased in Bengal about the middle of October and the retreating south-west monsoon rains commenced on the Madras coast about the same date, and continued with unusual steadiness during the last fortnight of October and the whole of November

There were no cȳclones or cyclonic storms in the Bay during this period with the exception of a remarkable diffused disturbance in the first week of December which passed up the Bay into Bengal and gave a short heavy burst of rain.

The chief feature of the meteorology of November was a succession of storms in Upper India which gave very heavy snow and excessive rain in that area and the adjacent hill districts.

December was a very dry month in Upper India. A diffused storm of very unusual character advanced from the Bay into Bengal, and gave a heavy burst of rain. Madras and Mysore continued to receive general showers until the last week of the month, when the dry weather of the north-east monsoon proper set in on the Carnatic.

The following gives a statement of the variations of the south-west monsoon rainfall in Northern and Central India from the normal, and of the retreating south-west monsoon rainfall in the Peninsula :—

	Variation from normal of ordinary S.W. monsoon rainfall for period June to September 1883.	Variation from normal of retreating S.W. monsoon rainfall for period October to December 1883.
	Inches.	Inches.
Punjab	—4'20	+0'01
Rajputana	—5'49	—0'23
Central India	—6'98	—0'51
North-Western Provinces and Oudh	—8'91	—1'33
Bengal	—6'22	—2'93
Assam	—9'27	—2'80
Central Provinces	+3'86	+0'56
Berar	+17'32	+4'78
Bombay	+3'82	+1'72
Madras	—1'05	+4'00
Burma	—1'59	+2'45

The pressure anomalies of November and December were everywhere small. The chief features were :—

1st—Pressure was in slight general defect over the whole of India.

2nd—Pressure was locally in defect in Upper India, the deficiency being greatest at Peshawar and Sialkot. It was also in local defect in North-Eastern India and Burma, the deficiency being somewhat greater in Burma than Bengal.

3rd—Pressure was in slight local excess over the whole of Central India, the North-Western Provinces and Bombay.

4th—The anomalies of the hill stations, although small, were persistent. The

following table gives the relative variations of pressure at certain hill stations as compared with the neighbouring plain stations :—

					VERTICAL PRESSURE ANOMALIES IN NORTHERN INDIA.			
					Lahore. Muzze	Murree Peshawar.	Chakrata Rutkee.	Ranikhet Bareilly.
					"	"	"	"
September	1883	.	.	.	—'023	+ '028	—'016	—'004
October	"	.	.	.	—'030	+ '001.	—'012	—'024
November	"	.	.	.	—'016	0	—'016	—'022
December	"	.	.	.	—'034	—'012	—'044	—'038
January	1884.	.	.	.	+ '018	+ '026	—'003	+ '015
February	"	.	.	.	—'017	+ '011	+ '005	—'022

The preceding data show that pressure was relatively in defect at the hill stations throughout the period from September to December. The relative variations were small and unimportant in January and February.

The following gives a summary of the chief features of the south-west monsoon period which were probably influential in modifying the cold-weather rainfall :—

1st—The occurrence of unusually heavy snow in May in the hill districts.

2nd—The weakness of the Bombay current throughout and the consequent very deficient rainfall in Upper India, more especially in July and August.

3rd—The retreat of the Bengal current from Bengal somewhat earlier than usual, and the establishment of the recurved current immediately afterwards on the Madras coast. It gave steady and normal rain to the greater part of the Peninsula in October and November, and retreated in the middle of December.

4th—The chief features of the pressure distribution in November and December were :—

(a) Slight deficiency of pressure in Upper India.

(b) Slightly higher pressure across the centre of the country from Lower Sind to South Bihar and Central Bengal.

These conditions continued in January and February, except that the local deficiency of pressure at the head of the Peninsula gradually extended southwards.

Chief features of the meteorology of the cold weather period, 1883-84.—

The following extract from the Report for the year 1884 gives a summary of the chief features of the meteorology of the cold weather of 1883-84 :—

" After six or seven weeks of unusually cool and dry weather in November and December 1883 the year opened with an increasing temperature in North-Western India, and a prevalence of southerly winds which brought a little rain to the Punjab, and later on, after the middle of the month, heavier and rather unusual rain in Central India, the Central Provinces, the Deccan and Hyderabad. It was not until nearly the end of the month that any considerable fall of snow took place on the Himalaya ; but this fall was very heavy in the extreme north and north-west, and being followed by further falls in February, the cool air that flowed over Northern India brought down the temperature ; and in Northern India the lowest temperatures of the year occurred in the first week of February, the whole month being, moreover, remarkably cool. During February, except in the north and west of the

Punjab, Sind and in parts of Bengal, there was scarcely any Northern or Western India. Dry westerly winds prevailed very steadily, and only on the east coast of the Peninsula and in Bengal the southerly winds of the coast brought a certain amount of vapour, which was precipitated as rain, chiefly in Eastern Bengal, Assam and the northern hills.

"The cool weather did not outlast the month of February. No rain having fallen on the plains the temperature rose rapidly in March; and in the Gangetic plain, which was swept by dry westerly winds of more than usual steadiness, in Chota Nagpur and the eastern districts of the Central Provinces, the mean temperature of the month was 2° or 3° in excess of the normal average. It is, however, noteworthy, as illustrating an association of conditions by no means unusual at this season, that, simultaneously with the abnormally high temperature and great dryness on the plains of Northern India, snow fell repeatedly and heavily on the higher ranges of the North-West Himalaya. There was a good deal of rain in the extreme north of the Punjab, where cooler weather than usual prevailed. But the snow and rain did not extend to the outer ranges further east, and at Simla and in Kumaon, as well as on the Central Himalaya, the weather was very dry and the temperature almost as unusual as on the plains. In April the weather both of the hills and plains continued of the same general character. On the former, at least in Kulu and Kashmir, but not on the lower ranges, frequent falls of snow and low temperature; on the latter, persistent westerly winds, very dry, and in the Gangetic valley and Chota Nagpur, unusually hot. This latter condition, however, did not obtain in Rajputana, Guzerat, Berar, Khandesh, and in Western India generally, where there was a certain abnormal depression of temperature notwithstanding the continued dryness. Some rain fell in Hyderabad and the adjoining districts of the Deccan, but except in these provinces there was less than the usual amount of rain throughout the Peninsula. The latter half of the month was rainy in Eastern Bengal and Assam.

"May was very similar in character to the two preceding months, but the temperature was more above the average in North-Western India than in April, and especially on the outer Himalaya. In the interior of Kashmir snow continued to fall at intervals till nearly the middle of the month, and dry west and north-west winds continued with unusual persistency throughout North-Western, and a considerable portion of Central India."

The following table gives a statement showing the variation of the total rainfall of the period 1st December 1883 to 31st March 1884 in different provinces from the normal:—

PROVINCE.	Variation from normal of cold weather rainfall, 1st December 1883 to 31st March 1884.	Percentage variation.
	Inches.	
Punjab	—1'33	—36
Rajputana	—0'42	—54
Central India	—0'24	—21
North-Western Provinces and Oudh	—1'99	—95
Bengal	+0'11	+ 4
Assam	+2'24	+36
Central Provinces	—0'38	—24
Berar	—0'44	—37

The rainfall of the cold weather period 1883-84 was hence very largely in defect in North-Western and Central India, and was in slight excess in Bengal and largish excess in Assam.

Storm of the cold weather of 1883-84.—A large number of depressions appeared in North-Western India and advanced eastwards across Northern India. The

great majority of them were very shallow depressions and of little importance except that although they gave little rain in the plains of Northern India, heavy rain or snow fell in the Afghan and Western Himalayan mountain areas. The following gives an account of the three most important disturbances, *vis.* the storm of the 8th to the 13th November, the storm of the 25th to 27th January and the storm of the 1st to the 5th February. The tracks of the second and third of these storms are given in chart 3, Plate LVII.

(I)—*Storm of the 8th to the 13th November 1883.*—The barometric movements on the 5th and 6th of November were somewhat irregular, but on the 7th pressure fell very rapidly on the North-West frontier and a depression formed in the South Punjab, Upper Sind and North Rajputana. The following observations show its position on the 8th:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity, at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity past 24 hours.	
Quetta	?	—'130	—'055	NNW	4	0
Murree	P	—'096	—'077	SE	3	4
Mount Abu	P	—'040	—'087	ENE	4	0
Jacobabad	29'824	—'143	—'209	WNW	2	0
Bickaneer	29'851	—'116	?	WSW	9	0
Lahore	29'847	—'115	—'177	E	1	0
Peshawar	29'848	—'106	—'190	Calm	1	0
Mooltan	29'818	—'162	—'224	WNW	1	0

Skies were clear over the whole of Northern and Central India, and winds were normal in direction in the Gangetic plain. North-westerly winds prevailed in Bengal. Skies were overcast in Southern India, and moderate rain was falling.

9th November.—The barometer had fallen over the whole of India by nearly equal amounts and the depression in North-Western India was hence unchanged in position and character. The following gives data of stations in the area of depression:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity, at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Quetta	?	—'072	—'112	NNE	6	0
Murree	P	—'029	—'096	Calm	3	2
Mount Abu	?	—'089	—'103	SE	6	0
Jacobabad	29'785	—'039	—'187	NE	3	0
Bickaneer	29'772	—'066	?	WSW	7	0
Sirsa	29'795	—'110	—'176	W	1	1
Lahore	29'792	—'055	—'184	E	3	0
Mooltan	29'805	—'013	—'191	N W	1	0

Winds were light over the whole of North-Western India and temperature increasing. Skies were clear except at the hill stations. Southern India continued to receive heavy rain.

10th November.—The barometer continued to fall in Northern India: but the changes were generally small in amount. Hence the depression occupied practically the same position as on the 9th. The following observations define its position:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity, at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Quetta	?	—'056	—'172	NE	5	0
Murree	?	—'053	—'158	Calm	4	2
Mount Abu	?	—'028	—'130	SW	7	1
Deesa	29'835	—'050	—'125	S	12	0
Bickaneer	29'773	+ '001	?	NNW	5	9
Lahore	29'793	+ 001	—'198	E	5	1
Mooltan	29'767	—'038	—'235	NW	1	0
Peshawar	29'777	—'037	—'208	ENE	2	4

Skies had clouded over in the North and the East Punjab, and the western districts of the North-Western Provinces, but were clear at Quetta and in Sind and Rajputana, as they had been for several days previously. Showers were reported from the South-East Punjab and the hill districts. Simla received 1 inch during the day.

11th November.—A largish rise of the barometer occurred in the Punjab, and the depression now covered South-West Rajputana and Cutch. The following observations define its position:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity, at Lat. 45°.	Change in past 24 hours.	Variation.	Direction 10 A.M.	Average hourly velocity previous 24 hours.	
Bhuj	29'789	+ '028	—'195	W	12	0
Deesa	29'849	+ '014	—'121	S	16	0
Bickaneer	29'819	+ '046	?	SE	8	8
Jacobabad	29'854	+ '050	—'138	N	4	10

Skies were generally clouded in the North and East Punjab and the hill districts and rain or snow had fallen in these areas. The following were the largest amounts recorded:—

STATION.	Precipitation during 24 hours preceding 10 A.M. of 11th.
Kiba	4'40 inches.
Simla	2'15 "
Jhelam	2'00 "
Abbottabad	1'70 "

Winds were very light and variable in Bengal and the Gangetic plain. Rain had nearly ceased in Southern India, and a cyclonic storm was forming in the Andaman Sea.

12th November.—The barometer continued to rise in Upper India. The depression in North-Western India occupied almost exactly the same position as on the previous day. The following observations show its position :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation.	Direction, 10 A.M.	Average hourly velocity, previous 24 hours.	
Quetta	?	+ '059	— '113	N	4	0
Murree	?	— '027	— '169	SE	19	10
Jacobabad	29'963	+ '109	— '042	NE	5	0
Deesa	29'871	+ '022	— '089	SSE	10	0
Pachpadra	29'861	+ '040	?	SW	?	1
Bickaneer	29'877	+ '054	?	SSW	2	2

Winds were very light and irregular in the Gangetic plain. The cyclonic storm in the Bay of Bengal had developed considerably and was advancing north-westward. Skies were clearing in the Punjab, but were still heavily clouded in the hills. The rainfall of the previous 24 hours had produced a large reduction of temperature in the Punjab.

Rain had again fallen over the same area as on the previous day, and some large amounts were registered :—

STATION.	Rainfall of 24 hours preceding 10 A.M. of November 12th.
Murree	3'87 inches.
Abbottabad	2'10 "
Gujrat	3'40 "
Rawalpindi	2'22 "

13th November.—Pressure had increased rapidly in North-Western India during the previous 24 hours by amounts ranging from '08" to '17". The largest increments were '15" at Bickaneer, '17" at Jacobabad, and '14" at Peshawar, Kurrachee and Mooltan. Anti-cyclonic conditions with fine clear weather were re-established over the whole of North-Western and Central India. Some showers were recorded, chiefly in the hill districts. Kilba reported the large amount of 4'2 inches. Fine weather continued over both the plains and hill districts of Northern India during the remainder of the month.

The storm apparently formed over the Punjab and Rajputana and remained nearly stationary during its existence, and it is hence not included in the storms the tracks of which are given in the track charts at the end of the Memoir.

It gave heavy rain in the North Punjab and moderate rain in the East Punjab. The following gives a statement of the rainfall during the storm :—

DISTRICTS.	RAINFALL ON				Total of period.
	9th.	10th.	11th.	12th.	
North and West Punjab	<i>Nil</i>	Inch. 0'12	Inch. 0'51	Inch. 0'64	Inch. 1'27
East Punjab	<i>Nil</i>	0'09	0'19	0'54	0'82
South-East Punjab	<i>Nil</i>	0'03	0'08	0'10	0'21

The precipitation was heavy on the hills. The following large amounts were reported :—

DATE.	HILL STATION.	Amount.
10th	Kilba	3'30 inches.
	Simla	2'40 "
11th	Kilba	4'40 "
	Simla	1'80 "
	Murree	1'54 "
	Abbottabad	1'70 "
12th	Murree	3'87 "
	Abbottabad	2'10 "
13th	Kilba	4'20 "

It is reported that snow due to this storm began to fall in Kashmir, Chamba and Kulu on the 10th. At Simla there was rain and snow two days earlier. In Kashmir snow fell and lay at Srinagar (5,276 feet), and in Kulu it fell down to 4,000 feet. In Busahir the total fall between the 10th and 13th yielded 13 inches of snow water according to the register of the Forest Department at Kilba, but it is difficult to resist the impression that this return, which was sent in by a native subordinate, a comparatively uneducated man, is not quite trustworthy. At Simla one register gave about 5 inches and another about 7 inches of snow water for the four or five days.

(II) Storm of the 25th to the 27th January 1884.—This was a very small storm, but it gave moderate rain to the Punjab.

The barometer was generally below the normal on the 22nd of January, but rose rather rapidly on the 23rd and 24th over the whole of Northern India. Pressure was from '05" to '15" above the normal on the morning of the 24th. Skies were clear over nearly the whole of India. Weather was fine with passing clouds in the Punjab on the 23rd, but the cloud amount increased and also extended eastwards and southwards over Rajputana and the North-Western Provinces. Temperature was considerably above the normal in Upper India.

Pressure began to give way on the 25th. The fall was greater in Sind and Baluchistan than elsewhere, but was very slight in North-Western India, more especially at the hill stations. Winds were very light at this time at the hill stations; for example, the

average wind velocity at Murree on the morning of the 25th was barely one mile per hour. This fall immediately preceded the advance of a depression into the South-West Punjab and Upper Sind and Rajputana from Baluchistan on the 25th. The following observations fix its position on the morning of the 26th :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, To A.M.	Average hourly velocity previous 24 hours.	
Quetta	?	—'004	+ '001	W	10	8
Jacobabad	29'997	—'081	—'051	NW	4	0
Bickan̄er	29'960	—'131	?	SW	5	3
Mooltan	29'919	—'189	—'142	NNE	4	10
Peshawar	29'970	—'159	—'098	WNW	1	10
Murree	?	—'110	+ '004	SE	22	

The centre of the depression was hence to the south-east of Mooltan in about Lat. $29\frac{1}{2}^{\circ}$ N. and Long. $72\frac{1}{2}^{\circ}$ E., and the amount of the depression at the centre nearly two tenths of an inch.

Skies were overcast in the North Punjab and partially clouded in the remainder of the Punjab, but were generally clear in Sind, Rajputana and the North-Western Provinces.

Winds had strengthened considerably in the Punjab, more especially at Murree, where they had increased from an average of one mile per hour on the 25th to 22 miles per hour on the 26th. Snowstorms were in progress at Murree and Quetta, and moderately heavy rain had fallen in the North Punjab. Peshawar had received 1·85 inches, Bannu 1·5 inches and Kohat 1 inch. The shift of wind at Kurrachee to north-west had reduced the aqueous vapour pressure at that station from '610' to '213'.

January 27th.—The observations show that the disturbance had advanced eastwards into the South-East Punjab and the north-western districts of the North-Western Provinces, where the barometer had fallen slightly, whilst it had risen briskly to rapidly in the North and West Punjab. The following observations define its position :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, To A.M.	Average hourly velocity previous 24 hours.	
Jeypore	30'018	—'051	—'084	S	6	0
Agra	30'048	—'017	—'007	E	6	0
Roorkee	30'099	—'016	+ '043	SE	2	6
Sirsa	30'044	+ '032	—'002	Calm	1	2

The depression was however now very slight and was evidently filling up as it approached the hills. Skies were clearing in the Punjab and the North-Western Provinces. Strong south-east winds continued at Murree, but at the level of the plains winds were much weaker. The winds in North-Eastern India were on this, as on the previous day, unaffected by the shallow depression in Upper India.

Moderate rain had fallen during the previous 24 hours in all except the south-western and south-eastern districts of the Punjab. The largest falls were 1·43 inches at Rawalpindi, 1·32 inches at Peshawar, 1 inch at Murree and 1·14 inches at Abbottabad.

A rapid recovery of pressure occurred on the 27th, and on the morning of the 28th strongly marked anti-cyclonic conditions prevailed in Northern India. Showers were received on the 28th and 29th in the Simla hill districts. Elsewhere fine clear weather prevailed.

The storm was hence small and, except on the 26th, very ill-defined. It crossed the North-West frontier further north than is usual, and advanced in an easterly course toward the Himalayas, and apparently broke up without crossing them. From its peculiar track it gave rain only to the Punjab, and the only heavy falls occurred in the northern districts, including Peshawar, Rawalpindi, Kohat and Bannu. The following gives the average rainfall in the Punjab from the 25th to the 27th:—

DISTRICT.	AVERAGE RAINFALL IN 24 HOURS PRECEDING 6 P.M. OF			TOTAL OF PERIOD.
	25th.	26th.	27th.	
	Inch.	Inch.	Inch.	Inch.
Punjab	0·01	0·19	0·31	0·51

The following statement of the snowfall in the hill districts during the storm is taken from the Annual Report for 1884:—

“A very heavy fall of snow occurred between the 26th and 29th on the East Punjab mountain region and rain at the northern stations of the Punjab. At Murree there were 2 feet 3 inches of snow. In Kulu the fall extended down to 4,500 feet, and a considerable amount fell on the higher ranges. At Kilba and Busahir 2 feet 2 inches fell on the 28th and 29th.”

(III.) *Storm of the 1st to the 5th February 1884.*—This, like the preceding, was a small storm which advanced along a track practically identical with that of the previous storm.

The barometric changes were irregular on the 30th and 31st of January, but pressure was generally increasing in India. It was falling locally in Baluchistan, the West Punjab and Sind, as is shown by the following observations of the morning of the 1st February:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity, previ- ous 24 hours.	
Quetta	?	—·078	—·057	S	2	3
Kurrachee	30·022	—·073	—·014	WNW	9	9
Hyderabad	30·047	—·064	—·038	WSW	8	2
Jacobabad	29·991	—·100	—·061	SE	2	9
Mooltan	30·009	—·083	—·043	SW	1	3
Murree	?	+·015	—·049	Calm	1	0

Winds were very light and unsteady in North-Western India. Westerly winds prevailed in the Gangetic plain and north-easterly winds in South Bengal. Skies were clear over the whole of Northern and Central India.

The preceding and subsequent observations suggest that a depression was advancing through Baluchistan, the centre of which, at 10 A.M., of the 1st, was in about Lat. 29° N. and Long. 64° E.

2nd February.—During the previous 24 hours pressure decreased in Northern India and increased in the peninsula. The following observations define approximately the position of the depression advancing through Baluchistan:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45° .	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previ- ous 24 hours.	
Quetta	?	—'055	—'112	SSW	8	10
Kurrachee	29'983	—'039	—'053	WSW	11	7
Hyderabad	29'979	—'068	—'106	SSW	10	2
Jacobabad	29'937	—'054	—'115	WSW	2	7
Mooltan	29'997	—'012	—'055	NE	3	2
Murree	?	+ '003	—'046	SE	?	10

The disturbance was hence now entering Upper Sind, and the centre was probably a little distance to the north-west of Jacobabad. Skies had clouded over in the Punjab and the hill districts, and were partially clouded in Sind. Rain had commenced to fall in Baluchistan and the North Punjab.

3rd February.—The following observations show that the centre of the disturbance had advanced eastwards into North-West Rajputana:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45° .	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previ- ous 24 hours.	
Jacobabad	29'948	+ '011	—'126	Calm	3	10
Mooltan	29'957	—'040	—'136	NW	4.	4
Bickaneer	29'886	—'027	?	SW	4	9
Pachpadra	29'957	—'014	?	SW	?	0
Jeypore	29'982	—'024	—'047	SW	4	7

The observations at Bickaneer and Pachpadra at this period were very unsatisfactory and are affected throughout by unknown and variable errors. The centre of the disturbance, so far as can be judged by the observations, was now a little to the west of Bickaneer in about Lat. $28\frac{1}{2}^{\circ}$ N. and Long. 72° E. Winds were, as hitherto, light in Upper India and showed a feeble and somewhat irregular cyclonic circulation over the area of depression. They were unchanged in direction in North-Eastern India. Cloud was extending over Rajputana and the North-Western Provinces. Fairly general, but light rain had fallen over the North and West Punjab. Murree registered 2 inches, and Abbottabad $1\cdot21$ inches,

and snow was falling on the higher elevations in the Punjab Himalayas. The barometer was falling briskly at Murree and the adjacent plain stations, and, as is shown by the 10 A.M. observations of the next day, this accompanied the formation of a secondary depression in the North Punjab.

4th February.—The primary depression had continued to advance eastwards during the previous 24 hours, and, as is shown by the following observations, the centre was in about Lat. 28° N. and Long. 76° E.:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45° .	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Jeypore	29'963	—'019	—'056	W	4	7
Agra	29'940	—'042	—'127	E	5	3
Delhi	29'940	—'037	—'098	S	3	9
Roorkee	29'961	—'040	—'099	SE	3	10
Ludhiana	29'940	0	—'093	Calm	1	10

The primary depression was hence, as hitherto, shallow and attended with light winds.

The following data give the position of the secondary depression, which the observations of the North Punjab stations of the 3rd show was then commencing to form:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45° .	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Murree	?	—'104	—'193	SE	3	10
Mooltan	29'882	+ '025	—'212	SW	1	3
Lahore	'949	—'033	—'132	Calm	4	10
Rawalpindi	'922	—'109	—'082	SE	2	10
Peshawar	'875	—'134	—'220	Calm	1	8
Dera Ismail Khan	'861	—'168	—'211	NE	3	0

The centre of the secondary depression was hence probably a little to the south-east of Dera Ismail Khan. The depression was shallower than is usually the case with secondary depressions in these cold weather storms. The chief feature was the feebleness of the winds (more especially at Murree). Skies were now clearing in Sind and the South-West Punjab. Moderately heavy rain had been received in the eastern and central districts of the Punjab and snow in the hills. Murree, Dharmasala and Kilba reported falls of snow varying from 2 to 3 feet in depth, and Lahore, Sialkot, Gurdaspur and Gujranwala amounts of rain ranging between 1 and 2 inches.

5th February.—Pressure had increased very rapidly during the previous 24 hours over the whole of North-Western India. In the Punjab the rise ranged from one-tenth

at Sirsa to three-tenths at Dera Ismail Khan. A rapid decrease of pressure had occurred in Assam and to a less extent in Bengal, but this was apparently an independent movement and had no connection with either the primary or the secondary depression of the previous day in Upper India. Skies had cleared over the whole of North-Western India, and light westerly winds prevailed in the Gangetic plain. With the exception of a few showers in the hill districts, and locally at Roorkee, no rain had fallen during the previous 24 hours. Fine dry weather prevailed on the 5th and during the remainder of the month in Western and Central India.

This storm consisted of a primary depression, which entered Upper Sind from Baluchistan on the 2nd and advanced eastwards from the foot of the hills to near Bareilly. The following gives the position of the centre of the primary depression during its existence:—

DATE.	POSITION.		Distance travelled in previous 24 hours.
	Latitude, N.	Longitude, E.	
	0	0	Miles.
1st February to A.M.	29	64	...
2nd "	28½	68	270
3rd "	28½	72	270
4th "	28	76	270

The depression thus advanced at the rate of about 270 miles per diem.

A shallow secondary depression formed rapidly in the North Punjab during the night of the 3rd, but filled up equally rapidly on the night of the 4th.

The following gives a statement of the rainfall in Upper India during the storm:—

AREA.	AVERAGE ACTUAL RAINFALL OF THE					TOTAL OF PERIOD.
	1st.	2nd.	3rd.	4th.	5th.	
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
Punjab	Nil	0·02	0·16	0·43	0·01	0·62
Sind	Nil	Nil	0·08	0·05	0·01	0·14
Rajputana	Nil	Nil	Nil	Nil	Nil	Nil

At Murree the snowfall during this storm amounted to 6 feet 6 inches. The snowfall was general in Kulu; extending down to 4,800 feet, and at 6,000 feet had a thickness of 18 inches. At Kilba in Bushahir it amounted to 4½ feet, but at Simla it was less than 1 foot, and was very slight in Kumaon, even on the passes.

The month of March was more disturbed than usual. A series of very small disturbances crossed Upper India.

The first appeared on the North-West frontier on the 2nd. It advanced through

Upper Sind on the 3rd, and North Rajputana and the South-East Punjab on the 4th and filled up before the morning of the 5th.

The following gives details of the position of the centre of the depression :—

DATE.	POSITION.		Station at which lowest barometer recorded.	Lowest barometer reduced to sea level and gravity, Lat. 45°.	Variation from normal.
	Latitude, N.	Longitude, E.			
3rd March	28½	69½	Jacobabad . .	29°905	— '011
4th „	28½	75	Bickaneer . .	29°763	?
5th „			Disappeared.		

The disturbance gave light to moderate rain on the 3rd in the Punjab, and snow in the hill districts of the Punjab and North-Western Provinces.

In the Punjab hills the snowfall of the 4th was heavy, down to 6,000 feet in Chamba, but in Kulu not below 8,000 feet. In Lahoul from the 1st to the 19th about 9 feet were measured. At Kilba in Bushahir there was a heavy fall on the 6th and 7th.

Two very shallow and ill-defined depressions advanced across Upper India between the 10th and 16th. The first appeared on the North-West frontier on the 8th, and gave rain in the Punjab and the western districts of the North-Western Provinces on the 9th and 10th. The second advanced through Upper Sind on the 13th and Central Rajputana on the 14th. It gave light showers in the Punjab plains and some heavy showers in the hills.

Very dry weather obtained during the remainder of the month and in April in North-Western India. But on the higher ranges falls of snow were frequent in April, and as the snowfall in March had also been unusually heavy, the accumulation in April was of exceptional thickness. This was testified to by several visitors in Kashmir. Thus Lieutenant Heygate wrote on the 21st from Sooknis: "The snow is tremendous, I never saw so much at this time of year;" and Mr. Eyre on the same date reported from Phoo Nullah: "Such snow, I can do nothing at present;" and even up to the 7th May, Lieutenant Merewether wrote from Dras: "There is a good deal of snow still, which makes it rather cold at night." In Chamba Major C. H. Marshall reported of the weather in April: "We have had very queer weather during the month, heavy storms of hail, rain and thunder. The actual rainfall has been light, all the same. We have had no heavy spring snow, though there has been fresh snow as late as the 25th April."

From Kulu it was reported, "The snowfall on the 7th and 8th April was heavy and general, extending down to 9,000 feet; snow fell on several dates during the month on the upper ranges. In Lahoul * * * the winter has been a very severe one, and owing to the snow being still on the ground, the cattle are suffering very much from want of fodder. Generally throughout Kulu, * * * the spring rains and snows have been frequent and heavy." From Kailang in Lahoul the Revd. A. W. Heyde wrote: "What snow we had in April nearly all fell in the first half of the month. In the second half the sky was often quite clear."

* The heavy snowfall of April was restricted to the ranges north-west of the Sutlej. In Kumaon there were only light falls on the higher ranges, down to about 13,000 feet; and generally on the Kumaon passes the snowfall of the season was light.

The most remarkable feature about this heavy snowfall and stormy weather on the Western Himalayas in April and May was that the observations at the plain stations in India gave hardly any indication of its occurrence. The weather in India was drier than usual, but temperature was below the average in North-Western India—evidently an effect of the stormy weather in the hills.

The facts are hence very suggestive, as showing that heavy and almost continuous snowfall for some time in the Western Himalayas may be due to causes in operation, of which the observations at Indian stations give little or no indication whatever. It is probable that the meteorology of Central Asia would throw full light on the conditions under which this precipitation usually occurs. * The establishment of observatories in that vast central plateau is very desirable for the solution of this and many other important problems in Asiatic meteorology.

1884-85.

Chief abnormal features of the meteorology of India in 1884.—The south-west monsoon of 1884 was very abnormal in character. The first indication of its establishment in the south of the Bay was the formation of a cyclonic whirl in the third week of May, which developed into a severe storm, and advanced from the centre of the Bay to the Arakan coast by a curved path. The dispersion of this storm was followed by the re-establishment of hot weather conditions and by a considerable delay in the permanent advance of the south-west monsoon current up the Bay. The rains set in fully in Bengal about the 22nd June, somewhat later than usual, and on the Bombay coast about 10th June. The rainfall of the month of June was very deficient in Madras, Bombay, Assam and Burma, and the humid currents did not in that month advance beyond Bihar and the Central Provinces.

In July the rains were very deficient over the area usually dominated by the Bengal current, or in Assam, Bengal, Bihar and the North-Western Provinces. Bombay received its normal amount and the Central Provinces and Berar excessive rain in consequence of the passage of an unusual number of storms from the Bay of Bengal through that area. In August the Punjab, Central India, the North-West Provinces and part of Rajputana obtained abundant rain, and the Central Provinces and Bombay on the whole slightly larger amounts than the normal. In Bengal, Assam and Burma there was a considerable deficiency. Abundant rain fell in all districts except Madras and Bengal during September. In Rajputana and the Central Provinces the excess was very large. The rains continued until the first week of October in Upper India. The rainfall of that month was either normal or in defect over the whole of Northern and Central India. The termination of the rains in Upper India was followed in a few days by the commencement of the so-called north-east monsoon rains in the Carnatic. Southern India received abundant and favourable rain from the 15th of October to the middle of December, when the rains ceased in Southern India, and dry clear weather was established for a brief period over the whole of India.

The following table gives the variations of the south-west monsoon rainfall from the normal for each of the larger divisions of the Empire :—

DIVISION.	VARIATION FROM NORMAL OF	
	Ordinary south-west monsoon of period June to September 1884.	Late south-west monsoon rainfall of period October to December 1884.
	Inches.	Inches.
Punjab	+ 2'34	—0'53
Rajputana	+ 3'23	—0'36
Central India	+ 7'73	—0'28
North-Western Provinces and Oudh	+ 6'19	+1'64
Bengal	— 6'73	—0'16
Assam	—16'27	—1'12
Central Provinces	+15'73	—0'13
Be:ar	+ 8'87	+4'15
Bombay	+ 4'91	+0'52
Madras	— 2'31	+9'01
Burma	+ 3'55	+3'26

The following gives a brief statement of the more important meteorological features of the south-west monsoon period of 1884, which may have influenced the character of the cold-weather storms of 1884-85 :—

- 1st.—The rainfall of the south-west monsoon was more or less in excess over the whole of India except Bengal and Assam. The deficiency was of little importance except in some parts of Bengal and Assam.
- 2nd.—The rainfall of the retreating south-west monsoon was unusually favourable in the peninsula and Burma, and more especially in Madras. The rainfall was in slight defect in Northern India.
- 3rd.—The south-west monsoon rains proper ceased slightly later than usual in Upper India. The rains, due to the retreating south-west monsoon, commenced at their normal date and continued slightly longer than usual, until the last week of December. They were hence favourably distributed in time, as in extension and amount.
- 4th.—Pressure was considerably in excess from October 1884 to June 1885 (with the exception of February) in the Indian land area. The following gives data :—

	Variation of mean pressure of India from normal.
	Inch.
September 1884	—'008
October	+ '036
November	+ '015
December	+ '035

		Variation of mean pressure of India from normal.
		Inch.
January 1885	.	+ '039
February "	.	- '013
March "	.	+ '022
April "	.	+ '019
May "	.	+ '062
June "	.	+ '004

Pressure was in slight to moderate local excess in Northern India and Burma, and was relatively to the general state in defect in the peninsula. The local pressure anomalies, although not large, were fairly persistent.

5th.—Pressure was in moderate defect at the hill stations as compared with the neighbouring plain stations. The following gives data for five pairs of stations :—

MONTH.	VERTICAL PRESSURE ANOMALY.				
	Leh minas Lahore.	Murree minas Peshawar.	Quetta minas Jacobabad.	Ranikhet minas Lucknow.	Chakrata minas Roorkee.
September 1884	- '016	- '008	+ '008	+ '010	- '016
October "	- '070	- '018	- '012	- '023	- '038
November "	- '054	- '012	- '005	- '018	- '027.
December "	- '011	+ '010	+ '013	- '023	- '028
January 1885	- '071	- '059	- '052	- '002	- '027
February "	- '036	- '041	+ '004	- '019	- '034
Mean of period	- '043	- '021	- '007	- '013	- '028

The deficiency of pressure at the hill stations was hence moderately large in amount, and was largest in the case of Leh, conditions which almost invariably precede and accompany a severe winter.

Chief features of the meteorology of the cold weather period, 1884-85.—
The following account is taken from Mr. Blanford's report on the meteorology of India of 1885 :—

"Snow to the thickness of 3 or 4 feet had fallen in Kumaon in September, and a considerable further fall took place both in the Central and North-West Himalaya in October and up to the 2nd November. It was probably a consequence of this early snowfall that the cool weather with its characteristic north-west winds set in in North-Western India about the middle of October, and that the temperature both of this month and November, and in a somewhat less degree that of December also, was much below the average, not only in Northern India, but also throughout the peninsula."

"After three months of unusual coolness at the end of 1884 the skies became clouded in the early part of January all over North-Western India, and more particularly on the North-Western Himalaya, while unusual serenity prevailed on the west coast of the peninsula, and especially in

Malabar ; indeed, more or less, throughout the western and southern portions of the peninsula. In the former region and in Baluchistan rain was heavy and frequent, and on the mountains the snow was very heavy. The precipitation was, however, restricted to North-Western India. In Bengal there was but little rain, and the peninsula was almost or quite rainless. The temperature of the month was much influenced by these conditions. It was greatly below the average on the north-western mountain region, where the cloud was thickest and the rain and snow heaviest ; it rather exceeded it where finer weather prevailed, in the Gangetic plain and the Central Provinces, and most in the latter, where the southerly winds which partially fed the rainfall, were felt down to the land surface. But, further west, Rajputana, Guzerat and Sind were swept, chiefly by cool northerly winds, and these provinces, therefore, shared, in a minor degree, the cooling effect of the rainfall to the north.

"February was a fine month on the plains of North-Western India. In the mountain region, indeed, there was merely an average amount of cloud ; the winds were much as in January, and rain and snow, though not general, nor (except in the beginning of the month) very heavy, fell almost daily up to the 21st ; but on the north-western plains there was but little rain, and that little restricted to the Western Punjab ; they were swept by north and north east winds of unusual persistency, and all down the west coast of India and in the Western Deccan and Berar north and north-west winds were abnormally prevalent.

"In March the weather was showery in the Central Provinces, at intervals alternating with rainy periods in Assam ; and there were showers also in the Deccan towards the end of the month. In the Carnatic also there were the usual spring showers. But, in the north-west, there was little or no rain on the plains till near the end of the month ; and even on the hills the weather was fine all through the middle of the month ; and the quantity of cloud, on the whole, did not exceed the average. On the plains of the Punjab the fine weather produced a rather higher temperature than usual ; but further south, in Sind, the Konkan and Deccan, the temperature remained abnormally low. There can be little doubt that, as in February, this was due to the northerly winds. It has been noticed in the foregoing pages that in Berar, the Central Provinces and the eastern part of the Central India plateau, north-west winds were less prevalent than usual, whereas they were more than usually prevalent on the coast of the Konkan and in Guzerat, and that it would seem as if the stream of air from North-Western India, instead of being diverted, as usual, on a south-easterly course towards Berar, the Central Provinces and Bengal, took an abnormal course down the west coast, while an air current from the Bay of Bengal swept up the Godavery valley and across the Eastern Deccan."

The following gives a statement of the variation of the rainfall from the normal in Northern India during the period 1st December 1884 to the 31st March 1885 :—

PROVINCE.	Variation from normal of cold weather rainfall, 1st December 1884 to 31st March 1885.	Percentage variation.
	Inches.	
Punjab	+0'09	+ 2
Rajputana	—0'26	— 36
Central India	—0'23	— 22
North-Western Provinces and Oudh	—0'60	— 29
Bengal	—0'13	— 5
Assam	—0'78	— 13
Central Provinces	+1'39	+ 89
Berar	+3'61	+273

The preceding table shows that the cold weather rainfall was normal in amount in the Punjab and more or less in defect in Northern and Central India. It was on the other hand considerably in excess in Berar and the Central Provinces.

Storms of the cold weather period of 1884-85.—This season was unusually stormy, but many of the smaller disturbances gave little rain in the plains, although heavy snow fell in the hills. The chief storms were as follows:—storm of the 5th to the 10th January, disturbance of the 27th to the 30th January, and the storm of the 2nd to the 7th February. The first was the most important. The following gives an account of these three storms, the tracks of all of which are shown in Plate LVII.

(1) *Storm of the 5th to the 10th January 1885.*—This storm, which gave a heavy burst of rain to Upper India, consisted of a primary depression which advanced from Baluchistan to Bihar, and of a secondary depression in the Punjab. The disturbance apparently passed through Persia, as Dushire had rain from the 1st to the 5th.

The first indications of its existence were shown by the Indian observations on the morning of the 5th. Pressure was falling generally, but the changes were small at all stations except Quetta, where the barometer had fallen a tenth of an inch and skies had become overcast. Over the whole of Northern India the weather was fine and skies generally clear, and pressure was about a twentieth of an inch above the normal. Westerly winds prevailed in the Gangetic plain, northerly winds in South Bengal, and easterly winds in the peninsula and on the Madras coast. Temperature was generally above the average, the excess being greatest in Sind (by amounts averaging 5°). A large decrease in the amount of aqueous vapour had occurred during the previous 24 hours at Murree and Simla, both of which stations reported calms.

6th January.—The 10 A.M. observations of this day show that the disturbance was now passing through Baluchistan. The centre at that hour was probably in Lat. 28½° N. and Long. 63° E. Pressure had increased except in Sind and the West Punjab. The following observations define the position of the depression and show that a fairly well marked cyclonic circulation was established in it:—

STATION.	PRESSURE.			WIND.		Cloud.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Velocity per hour during 24 hours.	
Murree	?	—040	+009	SE	14	10
Quetta	?	—066	—063	ESE	7	10
Jacobabad	30.112	—044	—026	Calm	1	10
Hyderabad	30.127	—035	—008	S	?	5
Kurrachee	30.088	—030	—017	WSW	6	1

Winds were unchanged in direction in Bengal and the peninsula, but had shifted round to south-east in the western districts of the North-Western Provinces. Skies had clouded over in the Punjab hills and the greater part of Upper India. Light showers had fallen in the North and East Punjab, and heavy rain at Quetta. Temperature had increased from 2° to 7° in North-Western India during the previous 24 hours, and was now from 5° to 8½° above the normal in that area. The changes of humidity were very irregular, but were apparently dependent chiefly on rainfall and change of direction of the winds. Thus, at Kurrachee, with the shift of wind from east to west-south-west, the aqueous vapour

pressure had increased from '313" to '615". An examination of the wind directions show that strong winds were blowing at Quetta and Murree, and that there was a feeble, but somewhat irregular, cyclonic circulation established over Sind, Rajputana, the Punjab and the greater part of the North-West Provinces. The only explanation of these facts is that a depression had formed to the west of the Indus valley, and that the chief seat of the cyclonic circulation was in the higher strata. The ascensional movement was, however, sufficiently large to affect the lower strata and to give a feeble and somewhat irregular cyclonic circulation in the lower atmospheric strata. The action evidently extended outward from Baluchistan and Upper India as a centre, and the extent of cloud and amount of rain indicated that the disturbance had formed in a humid current of considerable volume. The persistence of land winds at this period on the Bengal and Bombay coasts showed that the storm was not due to an intrusion of a humid sea current in the lower atmospheric strata.

7th January.—The centre of the primary depression which was passing through Baluchistan on the 6th was now entering Sind and advancing almost due eastwards. A secondary depression had commenced to form in the north of the Punjab, where very heavy rain was falling. The following data indicate the position and character of the primary depression :—

STATION.	PRESSURE.			WIND.		Cloud.
	10 A.M., reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Force.	
Quetta	29'915	—'210	—'267	SSW ?	16	10
Jacobabad	29'915	—'197	—'221	E	2	9
Hyderabad	30'003	—'124	—'132	S	12	8
Kurrachee	29'988	—'100	—'120	SW	7	6

The centre of the depression was probably a little to the west of Jacobabad in about Long. 68° E. The cyclonic circulation was very clearly marked, and the unusual strength of the winds at Quetta (which is situated in a valley and surrounded on all sides by hills), as well as the large fall of the barometer establishes that the disturbance was a large one. The reported wind direction is very anomalous.

The following gives similar data for the secondary depression which was forming in the North Punjab :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M., reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average velocity per hour past 24 hours.	
Leh	29'915	—'142	—'148	Calm	1	10
Murree	29'915	—'156	—'148	SE	28	10
Sialkot	30'020	—'200	—'094	E	4	10
Rawalpindi	30'001	—'228	—'079	ENE	3	9
Peshawar	29'947	—'263	—'194	W	2	10

The winds were hence light and irregular at the level of the plains, but this was evidently in part due to the interference of the two cyclonic systems. A very great increase had occurred in the force of the wind at Murree, where a gale had been blowing during the previous night. Skies were overcast or heavily clouded over the whole of North-Western India. Very heavy rain had fallen in the North and East Punjab. Murree had received $6\frac{1}{2}$ inches, Rawalpindi 2 inches and Peshawar $1\frac{1}{2}$ inches nearly. No rain had fallen in the North-Western Provinces, Central India and Rajputana. Quetta had again obtained heavy rain, and Sind a few local showers of little importance. The chief feature of the meteorology of the previous 24 hours was the formation of the secondary depression in the North Punjab, which accompanied the occurrence of excessive rain locally in that area, and of very heavy snow in the adjacent mountain districts.

8th January.—The primary depression, the centre of which was entering Sind on the 7th, had now advanced into West Rajputana. Its existence was to some extent obscured by the larger secondary depression which had formed in the North Punjab. The following observations define its position at 10 A.M. :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity.	
Pachpadra	29.855	—129	?	W	12	9
Ajmere	915	—180	—178	SW	8	2
Bickaneer	842	—131	?	NE?	8	10
Mooltan	834	—148	—322	NW	1	10
Jacobabad	902	—013	—229	NNW	3	0
Deesa	928	—108	—156	WSW	13	9

The centre of this depression was hence probably between Bickaneer and Ajmere.

The corresponding data for the secondary depression are given in the following table :—

STATION.	PRESSURE.			WIND.		Cloud.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity.	
Murree	...	—157	—301	SE	38	10
Sialkot	29.828	—192	—274	E	9	10
Rawalpindi	801	—2007	—279	Calm	6	10
Peshawar	811	—136	—316	Calm	1	10
Dera Ismail Khan	834	—149	—315	W	2	8

These observations show that a deep depression now overlay the North Punjab, in which the barometer was upwards of three-tenths of an inch below the normal at Murree at an elevation of 7,000 feet, and also at the level of the plains at Dera Ismail Khan and Peshawar. The most characteristic feature however was that the air was almost motionless at these two stations, whilst at the level of Murree it was blowing a heavy gale (the

average velocity of the previous 24 hours being 38 miles per hour (upwards of six times the normal velocity of the month, *viz.* 6 miles per hour), a striking proof that the cyclonic storm was a disturbance in the middle and higher strata, and that the disturbance in the lower strata was comparatively feeble and unimportant and subsidiary to the former. Strong cyclonic winds were also blowing at Quetta, Simla and Chakrata. The lower cyclonic air movement extended over the Punjab, Upper Sind, Rajputana, Central India, the Central Provinces and the North-Western Provinces, Eastwards of Bihar west to north-west winds prevailed and easterly winds on the Bombay coast, thus showing that the disturbance had not affected the winds in the coast districts, and hence also that it was not due to the advance of a humid sea current in the lower atmospheric strata from the Bay of Bengal or the Arabian Sea.

Skies were overcast in East Baluchistan, the Punjab, the North-Western Provinces (west of Agra) and part of Rajputana. They had cleared in Sind.

Fairly general rain had fallen during the previous 24 hours over the whole of the Punjab, the greater part of Rajputana and the hill districts of the North-Western Provinces. In the North Punjab amounts varying from 1 to 4 inches were received, Murree as on the previous day receiving the largest fall.

The humidity and aqueous vapour changes were, as usual during these storms, very large and irregular, but apparently chiefly dependent on rainfall and shift of wind. The following gives the most striking changes during the previous 24 hours:—

STATION.	WIND DIRECTION AT 10 A.M. OF		AQUEOUS VAPOUR PRESSURE AT 10 A.M. OF		Change in 24 hours.
	7th.	8th.	7th.	8th.	
Kurrachee	SW	NW	'708	'210	—'498
Jacobabad	E	NNW	'332	'048	—'284
Dera Ismail Khan	WNW	W	'335	'173	—'162

This very large change was evidently due to the influx of winds descending from the dry and arid area of Baluchistan and Afghanistan.

9th January.—The primary depression, so far as can be judged from the observations, had advanced almost due east, and the centre was probably near and to the south-east of Agra. The following data define its position:—

STATION.	PRESSURE			WIND.		Cloud amount at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity previous 24 hours.	
Jhansi	30'026	+ '058	—'046	NW	?	0
Nowgong	'039	+ '032	—'060	WSW	3	7
Lucknow	'061	—'032	—'047	SSE?	3	2
Bareilly	'057†	—'021	—'019	Calm	4	10
Agra	'019	+ '013	—'090	NE	7	3

This depression was now less obscured by the secondary depression, which was now fast filling up. Skies were partially clouded in the primary depression, and no rain had

fallen in the area covered by the depression during the previous 24 hours except some light showers in Central and South-West Rajputana.

The following gives data for the secondary depression:—

STATION.	PRESSURE.			WIND.		Cloud amount at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity, previous 24 hours.	
Leh	P	—'014	?	NE	1	10
Murree	P	+ '036	—'258	SE	1	10
Sialkot	30°020	+ '192	—'091	E	7	4
Rawalpindi	29°944	+ '143	—'136	SE	8	9
Peshawar	29°954	+ '143	—'175	N	1	10
Dera Ismail Khan	29°990	+ '156	—'158	W	4	6

The depression was hence, so far as can be judged, absolutely unchanged in position. It was however filling up rapidly, as pressure had increased nearly two-tenths of an inch in the central area. Skies were also clearing and were now only clouded in the East and North Punjab and western districts of the North-Western Provinces and the adjacent hill districts. With the change of wind, a remarkable decrease of humidity had occurred at many stations. The following gives examples:—

STATION.	WIND DIRECTION AT 10 A.M. OF		AQUEOUS VAPOUR PRESSURE AT 10 A.M. OF		Change in 24 hours.	HUMIDITY AT 10 A.M. OF		Change.
	8th.	9th.	8th.	9th.		8th.	9th.	
Mount Abu	SW	SW	'421	'034	—'387	83	10	—73
Deesa	WSW	SW	'596	'161	—'435	76	35	—41
Ajmere	SW	SW	'368	'105	—'263	43	22	—21
Bickaneer	SW	SW	'404	'204	—'200	58	55	—3
Mooltan	NW	SW	'336	'147	—'189	74	52	—22

The south-west winds at these stations were evidently due to an inflow of air from the dry and arid area of Baluchistan, the southerly element in the direction being largely determined by the continuance of the low pressure area in the North Punjab. That they were not sea-winds is shown by the fact that at the same hour winds were SE at Bhuj, NW at Rajkot, ENE at Surat and N at Bombay. Accompanying this change of humidity there had been a remarkable decrease of temperature, *e.g.*:—

STATION.	MEAN TEMPERATURE OF 24 HOURS PRECEDING 10 A.M. OF THE		Change in past 24 hours.	CLOUD AMOUNT AT 10 A.M. OF	
	8th.	9th.		8th.	9th.
Mount Abu	62°5	48°0	—14°5	10	0
Deesa	74°8	62°3	—12°5	9	0
Mooltan	60°0	48°5	—11°5	10	0
Bickaneer	73°0	60°3	—12°7	10	0
Ajmere	69°0	?	?	2	0

The data show that a great fall of temperature had occurred in the rear of the storm, where skies had already cleared.

In the plains the winds continued to show the influence of the storm. South-east winds prevailed in the South Punjab and North-Western Provinces and east winds in Bihar. In Bengal northerly winds continued. Hence the direction of the extension of easterly winds in the Gangetic plain, it should be noted, was from west to east, so that the easterly winds of the disturbance were evidently not sea-winds, but simply local winds generated by the disturbance, commencing near the centre and extending eastwards with the increasing intensity and advance of the disturbance. Hence, an important inference that the easterly winds in the Gangetic plains accompanying this cyclonic movement were a subsidiary result, and not the cause of the disturbance.

Rain had fallen during the previous 24 hours over nearly the whole of the Punjab, Rajputana and the north-western districts of the North-Western Provinces. The precipitation was large in the hill districts and in the East Punjab, and falls exceeding 2 inches occurred at a large number of stations. Chamba received 3·77 inches, Chakrata 3·8 inches and Gurdaspur 3·1 inches.

10th January.—A rapid increase of pressure occurred during the 24 hours preceding 10 A.M. over the whole of North-Western India ranging in amount from one tenth to a quarter of an inch in the West Punjab. These changes obliterated the secondary depression and re-established anticyclonic conditions in Upper India.

The primary depression advanced through the eastern districts of the North-Western Provinces during the day, but it was now very shallow and filling up. The air motion in it at the level of the plains was so very slight and irregular that it is not possible to locate the centre with certainty. The following observations however enable its probable position to be approximately ascertained:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
	"	"	"			"
Benares	30·069	+·003	—·010	Calm	4	8
Allahabad	30·057	—·006	—·049	E	2	10
Lucknow	30·050	—·011	—·055	NNE	3	8
Sutna	30·066	+·033	—·022	W	6	10
Gorakhpore	30·090	—·021	+·007	N	0	5
Patna	30·104	—·020	+·027	NW	1	8

The depression was hence by no means clearly defined. Light to moderate rain was, however, received in the eastern districts of the North-Western Provinces and Oudh, and some light showers in Bihar. These facts, taken in conjunction with the observations, appear to establish that the disturbance had advanced eastwards into Bihar.

Temperature continued to fall rapidly to the west of the storm area. Skies had cleared in the Punjab, but were heavily clouded in the North-Western Provinces, Bihar, and the

Central Provinces. Westerly winds were extending down the Gangetic plain and producing a very large decrease of aqueous vapour present in the air, as is shown by the three following examples:—

STATION.	AQUEOUS VAPOUR PRESSURE AT 10 A.M. OF		Change in 24 hours.
	9th.	10th.	
Agra	'543	'215	—'328
Delhi	'444	'227	—'217
Roorkee	'441	'334	—'107

Pressure continued to increase during the day and skies cleared in the North-Western Provinces and Bihar, so that on the morning of the 11th fine clear weather was established over the whole of Northern and Central India, and there was practically no trace of the continued existence of the primary depression.

The primary disturbance was hence a shallow depression which probably advanced from Persia across Baluchistan into India, and thence advanced along an east by south track from Upper Sind into Bihar, when it filled up. When entering Sind it gave rise to the formation of a deep secondary and stationary depression in the North Punjab. The barometer fell for about 36 hours and rose again during an equal interval, so that its existence was between three and four days.

The following gives approximately the position of the central area of the primary depression:—

DATE.	POSITION OF THE CENTRAL AREA.		Number of miles traveled during 24 hours.
	Lat. N.	Long. E.	
6th January	28½	63	...
7th "	28	67½	300
8th "	27½	73	340
9th "	26½	78½	340
10th "	26	82½	250

It hence advanced with a nearly uniform velocity of approximately 320 miles per diem.

The rainfall due to the disturbance chiefly occurred in the Punjab and accompanied the formation and development of the secondary depression. The following shows roughly the distribution of the rainfall during the storm:—

AREA.	AVERAGE RAINFALL.					Total amount, 6th to 10th.
	6th.	7th.	8th.	9th.	10th.	
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
Punjab	0'11	0'36	0'57	0'76	0'01	1'81
North-Western Provinces	<i>Nil</i>	<i>Nil</i>	0'08	0'26	0'07	0'41
Oudh	<i>Nil</i>	<i>Nil</i>	0'07	0'01	0'14	0'22
Sind	<i>Nil</i>	0'06	0'01	<i>Nil</i>	<i>Nil</i>	0'07
Rajputana	<i>Nil</i>	<i>Nil</i>	0'11	0'10	<i>Nil</i>	0'21
Central India	<i>Nil</i>	<i>Nil</i>	0'01	<i>Nil</i>	0'08	0'09
Bengal	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	0'01	0'01

The rainfall was hence small in amount except in the Punjab, which received an average of very nearly two inches.

Heavy snow fell over the high lands to the north and west of the Punjab. On the Tartarra, Khaibar Hills and in Tirah in Afghanistan the roads were impassable for three days. The snowfall at Sandapul was estimated at 3 feet. In the Kulu Valley the snow lay down to the river bed (or below 4,000 feet), and at Kailang in Lahoul not less than 7 feet of snow fell in three days. For several days the villagers were confined to their houses and had no other water than melted snow. At Murree $1\frac{3}{4}$ feet of snow fell.

The storm hence gave a moderately heavy fall of rain to the Punjab and western districts of the North-Western Provinces, and more or less excessive snow over the large mountain region of Afghanistan, Baluchistan and the North-West Himalayas. It is also evident, judging by the snowfall, that condensation occurred most rapidly and vigorously over the higher mountain districts—another proof of the assumed character of these storms stated above.

The temperature changes which accompanied the storm were even larger than are usual in such storms. They were in part due to the heavy snowfall in the mountain districts to the north and east of the Punjab. The following gives five examples of the temperature changes which occurred during the advance of the storm:—

Station.	PROGRESSIVE CHANGE OF THE MEAN ACTUAL TEMPERATURE OF THE 24 HOURS PERIOD ENDING AT 10 A.M. OF THE					
	5th.	6th.	7th.	8th.	9th.	10th.
Jacobabad	+3°0	+1°8	—5°8	—0°2	—9°0	—3°3
Deesa	+0°3	+5°0	+2°7	—0°2	—12°5	—14°5
Bickaneer	—2°0	+3°0	+4°7	+2°2	—12°7	—7°7
Agra	+0°3	+0°7	+3°0	+2°5	—0°2	—5°3
Allahabad	+2°8	0	0	+1°0	+2°7	+6°8

Fine weather prevailed from the 10th until the 14th, when the weather became slightly unsettled in Upper India. The barometer fell rapidly on the 13th and 14th. Thunder-showers occurred in Central India and the Central Provinces from the 13th to the 16th, on the 14th and 15th in Rajputana, on the 15th and 16th in the Punjab and North-Western Provinces, and in Bihar on the 16th.

This slight disturbance originated in Central India and the Central Provinces and extended northwards and eastwards on the 14th, 15th and 16th, after which weather became settled for a few days. This disturbance was different from the preceding, in that there was no definite area of depression and it did not give rise to general rain. It was merely a period of very slightly disturbed weather manifesting itself in local thunder-storms. It is hence not included in the list of cold weather storms. Pressure was very high in the Punjab during this disturbance, ranging from 30·15" to 30·35".

"A very heavy and general fall of snow during this storm took place on the 15th in the Afghan mountain ranges. On the Khaibar mountains it is stated to have been heavier than has been known for the previous ten years, and to have been in places 20 yards (?) deep.

(II). *Disturbance of the 27th to the 30th January 1885.*—The weather was slightly unsettled in the hill districts from the 23rd to the 25th. During this period pressure was

above the normal in Northern India, and the general character of the distribution of pressure was practically identical with the normal distribution of the period with the exception that there was a considerable deficiency in Sind. This had been a conspicuous feature of the pressure distribution during the months of December and January.

Pressure continued to increase over the greater part of Northern India and at Quetta on the 26th, and was in excess on the morning of the 27th by amounts ranging from '03 in Bengal and Bihar to '14 in the East Punjab. Weather continued unsettled, as snow-storms occurred at the Punjab hill stations and local thunderstorms in the South Punjab and North-Western Provinces. The barometer began to fall rapidly in North-Western India on that day and the observations of the morning of the 27th indicated that a shallow depression was in existence in Sind and East Baluchistan. The following gives observations taken at stations in that area:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from Normal.	Direction.	Average hourly velocity previous 24 hours.	
Quetta	?	—'097	+ '037	SSW	4	10
Kurrachee	30'003	—'127	—'037	WSW	8	1
Hyderabad	30'077?	—'121	—'058	W	7	5
Jacobabad	29'999	—'150	—'059	E	6	9

Temperature had increased rapidly in Sind (5°) and the South-West Punjab (4°). A considerable decrease had occurred in the amount of aqueous vapour at the Punjab hill stations and at Mount Abu, greatest at the latter station. Skies were overcast at the Punjab hill stations, and more or less clouded in Sind and the Punjab, but were generally clear in other districts. South-west winds prevailed in South Bengal and light unsteady easterly winds in Bihar and the eastern districts of the North-Western Provinces. Light to moderate showers of rain had fallen in Baluchistan, the West Punjab and Sind and at the Punjab hill stations.

28th January.—The observations of the 28th show that the disturbance had travelled rapidly eastwards during the previous 24 hours and covered East Rajputana at 10 A.M. of that day. The following observations define its position:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Chakrata	?	—'185	—'109	E	8	10
Jeyapore	29'925	—'149	—'180	N-W	5	3
Jhansi	'909	—'208	—'163	SS-W	?	6
Agra	'939	—'165	—'107	S	7	10
Delhi	'941	—'230	—'113	N	6	9
Roorkee	'901	—'234	—'142	S.E	5	10

The observations indicate that the centre of the primary depression was about midway between Jhansi and Jeypore in Lat. 26° N. and Long. $77\frac{1}{2}^{\circ}$ E., and that there was a marked tendency towards the formation of a small secondary depression near the hills at Roorkee. A rapid recovery of pressure had set in over Baluchistan and Sind, and skies had cleared over the whole of that area. Winds had shifted to directions between north and west, and caused a rapid decrease of temperature and humidity.

General rain had fallen during the previous 24 hours in the Punjab and North-Western Provinces, and some light and scattered showers in Rajputana and Central India. Large falls were recorded at the following stations in the south-eastern districts of the Punjab and adjacent districts of the North-Western Provinces, of which the following were the most noteworthy :—

Delhi	.	.	.	.	.	.	.	4'80 inches.
Muzaffarnagar	.	.	.	.	.	.	.	2'70 "
Meerut	.	.	.	.	.	.	.	2'28 "
Gurgaon	.	.	.	.	.	.	.	2'50 "
Bijnor	.	.	.	.	.	.	.	2'37 "
Saharanpur	.	.	.	.	.	.	.	2'28 "

Quetta, Murree, Simla and Chakrata reported snowstorms during the previous day.

29th January.—The disturbance had advanced rapidly eastwards during the previous 24 hours into Central and South Bihar at 10 A.M. of the 29th.

Pressure had increased very rapidly in North-Western and Central India by amounts ranging from one to three-tenths of an inch (at Roorkee, Peshawar and Sirsa), and was largely above the average. The following observations define the position of the depression on the morning of the 29th :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M., reduced to sea-level and gravity at Lat. 45° .	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Gaya	30'045	—'009	—'038	W	5	6
Patna	'090	—'054	+ '013	S-W	6	0
Darbhanga	'092	—'065	+ '027	NN-E	4	10
Gorakhpur	'095	+ '025	+ '012	N	1	0
Benares	'111	+ '060	+ '032	WS-W	5	01

In consequence of the rapid general increase of pressure in the Indian region, the depression was now very slight and barely traceable, except from the wind and rain data. Westerly winds had set in over the whole of the North-Western Provinces and produced a rapid reduction of temperature and humidity. Skies had cleared in the Punjab and North-Western Provinces and were lightly clouded in Bihar and Bengal. A few showers had been received in the North-Western Provinces, and slight but fairly general rain in Bihar, North Bengal and Assam.

30th January.—The indications of the existence of the depression were now even feeble than on the 29th, but the observations appear to establish that it was entering

Upper Burma from East Bengal at 10 A.M. The following observations give data in support of this :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at lat. 45°	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Silchar	30°034	—°052	—°025	E	3	0
Dacca	°030	—°007	—°002	N-W	2	4
Jessore	°055	+°009	+°034	N	2	8

No rain had fallen during the previous 24 hours except some light showers in Assam.

This storm, so far as can be judged from the records, originated in Sind and Baluchistan, and advanced somewhat more rapidly than is usual with cold weather storms in an easterly direction across Northern India. It developed to some extent for a very short period while passing through Rajputana, and at the same time there was a tendency towards the formation of a secondary depression at the foot of the hills near Roorkee and Delhi.

The following gives the position and rate of motion of the central area :—

DATE.	POSITION.		Distance travelled.
	Lat. N.	Long. E.	
27th January	27	68½	...
28th "	26½	77½	550
29th "	25½	85	480
30th "	24½	92	460

The average rate of motion of the storm was hence about 20 miles per hour.

The distribution of the rainfall accompanying the storm is shown by the following data :—

PROVINCE.	AVERAGE ACTUAL RAINFALL.				Total of period.
	27th.	28th.	29th.	30th.	
	Inch.	Inch.	Inch.	Inch.	Inch.
Punjab	0°09	0°30	0°62	Nil	0°91
Sind	0°12	0°01	Nil	Nil	0°13
Rajputana	0°03	0°01	Nil	Nil	0°04
North-Western Provinces	0°02	0°56	0°05	Nil	0°63
Oudh	0°07	0°62	0°04	Nil	0°73
Bengal	Nil	0°01	0°11	Nil	0°12
Assam	Nil	Nil	0°22	0°05	0°27
Burma	Nil	Nil	0°30	Nil	0°30

The following data give some of the largest and most noteworthy temperature changes which accompanied the storm :—

DATE.		Station.	VARIATION FROM NORMAL OF			Change in previous 24 hours.
			Maximum.	Minimum.	Mean.	
			°	°	°	°
3rd February	Cold	Quetta	-7.0	-8.0	-7.5	-7.5
		Sialkot	-8.4	+1.0	-3.7	-4.2
	Warm	Roorkee	-0.2	+7.8	+3.8	+4.5
		Jeypore	+0.6	+4.3	+2.5	+3.5
4th "	Cold	Murree	-8.0	-2.0	-5.0	-5.0
		Dera Ismail Khan	-13.5	-4.5	-9.0	-10.0
	Warm	Indore	+5.5	+4.8	+5.2	+8.2
		Mount Abu	+4.2	+2.9	+3.6	+9.6
5th "	Cold	Darjeeling	-7.5	-1.5	-4.5	-4.5
	Warm	Mount Abu	-6.5	-3.0	-4.8	-4.8
		Agra	+0.3	+5.1	+2.7	+0.1
6th "	Cold	Allahabad	-4.0	+5.5	+0.8	-1.5
	Warm	Calcutta	+1.3	+7.1	+4.2	+5.1
7th "	Cold	Benares	-4.5	+3.3	-0.6	-4.7

The following table gives the largest changes in the amount of aqueous vapour present in the air :—

			Actual at 2 A.M. of date.	Change since 2 A.M. of previous day.
			"	"
2nd February	Quetta		271	+057
	Lahore		373	+095
	Jeypore		250	-121
3rd "	Chakrata		191	+103
	Dera Ismail Khan		349	+091
4th "	Quetta		133	-083
	Mount Abu		319	+144
	Kurrachee		265	-351
	Jacobabad		216	-181
5th "	Mount Abu		229	-090
	Deesa		254	-171
6th "	Benares		501	+142
	Calcutta		739	+147
7th "	Benares		373	-128

The available data show that in almost all cases the large aqueous vapour changes

were due either to the occurrence of rainfall, or to the shift of wind, which accompanied the advance of the storm.

III.—Disturbance of the 2nd to the 7th February 1885.—Pressure increased for some days, after the previous depression had dispersed, over the whole of India and was in excess everywhere. The excess ranged from '05" to '10" in Northern India. Moderate cold weather gradients obtained. Winds were very feeble in Upper India, and were irregular and unsteady in the Gangetic plain. Light northerly winds prevailed in Bengal and easterly winds in the Central Provinces and Central India. Temperature was excessive in Upper India and Baluchistan and was generally in slight defect over the remainder of the country. The air was very dry in Upper India and at the hill stations, and skies had clouded over rather rapidly in Baluchistan, the North Punjab, and Punjab Himalayas, but were clear over the remainder of Northern and Central India.

3rd February.—The barometer fell to a moderate extent over the whole of Northern India, the fall being slightly greater in Sind than elsewhere; but even in that area it did not exceed '08". Winds were very light and irregular over the whole of North-Western India. They were, however, increasing rapidly in force at Murree (from an average of 4 miles per hour on the 2nd to 18 miles per hour on the 3rd). The cloud canopy had extended considerably during the previous 24 hours, and skies were now heavily clouded over the whole of North-Western India. Moderately heavy rain or snow had fallen at the hill stations of Quetta and Murree, and rain was beginning to fall in light showers in the Punjab plains.

4th February.—The barometer fell rapidly in Rajputana and the Punjab, and a shallow depression covered Rajputana, the centre of which was, so far as can be judged, near Ajmere. Pressure was approximately uniform over this large area of depression. The following gives readings in two sections, the first running from north to south, and the other from east to west:—

	STATION.	10 A.M. pressure reduced to sea-level and constant gravity, at Lat. 45°.
1st section from north to south	Sisikot	29.934
	Sirsa	'931
	Jeypore	'916
	Indore	'923
2nd section from east to west	Agra	'935
	Ajmere	'935
	Pachpadra	'938

The area covered by this depression was 600 miles long and 400 miles in average width, and hence covered an area as large as the British Isles. Over this area pressure was from a sixth to a tenth of an inch below the normal. Winds were very light and irregular. Temperature was falling steadily at the hill stations and in the Punjab, but was increasing rapidly in Rajputana and the North-Western Provinces. The humidity changes were large, but were in part due to changes of temperature, in part to the occurrence of rain and

in part to the shift of wind from south to west or north-west. Light to moderate showers had fallen over a large part of the Punjab, and moderate snow in the Punjab hills.

5th February.—The barometer was falling at this time over the whole of India. The most important changes were due to the eastward advance of the depression, and the rapid fall of the barometer in Upper India due to heavy rainfall and tending to give rise to a secondary depression in the Punjab. The effect of the two was to give rise to a trough of low pressure running north-westward from Sambalpur to Ludhiana.

Skies were now beginning to clear in Upper India, and a considerable decrease of temperature had already taken place at the hill stations and in Upper India. Murree had received two feet of snow and Simla a few inches. Showers had fallen in the Punjab and some parts of the North-Western Provinces, but the amounts were generally small.

6th February.—Pressure had increased rather rapidly in Upper India. The observations indicate that the primary depression had been transferred to Bihar and West Bengal.

Sourtherly winds had set in over South Bengal and were giving much cloud in that area, and thunderstorms had occurred over the greater part of Bengal and Assam. Bihar received light showers.

7th February.—The shallow depression had advanced during the previous 24 hours, from Bihar to East Bengal.

Skies were generally overcast in Bengal and had cleared in Upper India. Thunder-showers had again been received in South Bengal and Assam, but the amounts were smaller than on the 6th.

The depression apparently passed into Upper Burma, but in the absence of observations it is not possible to fix its position.

The depression apparently passed into India from Baluchistan. Its formation was accompanied by a slight tendency to a subsidiary depression on the East Punjab. The two depressions give rise for a short period to a long trough running north and south with very feeble cyclonic indications. The primary depression advanced eastwards across Northern India, whilst the subsidiary depression filled up after a brief existence of 24 hours.

The following table gives approximate data of the track of the centre of the primary depression:—

DATE.	POSITION OF CENTRE.		Distance travelled in previous 24 hours.
	Lat. N.	Long. E.	
3rd February	27½	68½	Miles. ...
4th "	26½	74	370
5th "	25½	79	320
6th "	24½	84½	330
7th "	24	89½	340

The average rate of motion of the primary depression was about 340 miles per diem. The following gives a summary of the rainfall:—

RAINFALL OF 24 HOURS PRECEDING 6 P.M. OF THE							Total of period 2nd to 17th.
AREA.	2nd.	3rd.	4th.	5th.	6th.	7th.	
Punjab	Inch. 0·2	Inch. 0·2	Inch. 0·2	Inch. <i>Nil</i>	Inch. <i>Nil</i>	Inch. <i>Nil</i>	Inch. 0·6
Rajputana	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>
North-Western Provinces	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>
Bengal	0·5	<i>Nil</i>	<i>Nil</i>	0·3	0·7	0·1	1·6
Assam	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	0·1	0·1	0·1	0·3
Central India	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>
Central Provinces	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>	<i>Nil</i>

The changes of temperature and of amount of aqueous vapour were less marked than in the case of the previous storm.

1885-86.

Chief abnormal features of the meteorology of India in 1885.—The cold weather of 1885 was, as has been already stated, unusually severe. Several storms crossed Northern India in January and February. The chief feature of these storms was the unusually heavy snowfall in the hill districts. April and May were very disturbed months, and in the latter month especially snow fell in excessive quantities in the Western Himalayas. Pressure was hence locally excessive in North-Western India in April and May, and was more or less in defect in North-Eastern India, Burma and the peninsula.

Temperature was very considerably below the normal in Northern and Central India. The deficiency for the month of May in the mean temperature averaged 8° in the Punjab and 5° in the North-Western Provinces.

The rains commenced between the 10th and 15th of June in Bengal. Burma and Madras obtained in that month rainfall above the normal. The rainfall was very irregularly distributed in Bengal. The rains were greatly delayed on the Bombay coast and did not set in until the last week of the month. Both the Bengal and Bombay currents were weak during nearly the whole of July, and there was a very dry hot period in Upper India from the first to the third week of July. The rainfall of July was normal in amount in Bombay, the Central Provinces, Berar, Burma and Assam, and deficient in all other districts, the deficiency being relatively to the normal rainfall greatest in North-Western India, including the Punjab, Rajputana, Central India and Guzerat. The monsoon currents were very strong in August, and excessive rain was received over nearly the whole of Northern India and Burma, whilst the rainfall was more or less in defect in the peninsula.

The rains ceased unusually early in September in Upper India and the Bombay current fell off very rapidly in strength. Weather was very disturbed in the Bay, and a very severe cyclone formed and advanced to the Orissa coast. The storm wave accompanying this cyclone (known as the False Point cyclone of 1885) overwhelmed the small station of False Point and caused a large destruction of life and property on the Orissa

coast. The rains were in moderate excess in North-Eastern India and the Deccan, but were largely in defect in other districts.

The retreating south-west monsoon rains commenced about the normal date in October in Madras. They were lighter than usual in North Madras. South Madras, Mysore and Coorg, on the other hand, received larger amounts than usual in October. Similar conditions obtained in November. North and Central Madras received less than their normal amount, whilst South Madras and Ceylon obtained excessive rain. The retreating south-west monsoon rains finally ceased on the 25th December. The whole of Madras, Ceylon and Mysore received abundant rain in December.

The following gives a comparative statement of the rainfall of the south-west monsoon :—

Division.	VARIATION FROM NORMAL OF AVERAGE ACTUAL	
	Ordinary south-west monsoon rainfall period, June to September 1885.	Retreating south-west monsoon rainfall period, October to December 1885.
	Inches.	Inches.
Punjab	—3'01	+0'26
Rajputana	+1'35	+0'23
Central India	—1'78	+2'57
North-Western Provinces and Oudh	+8'84	+0'97
Bengal	+3'51	—0'87
Assam	+2'95	—1'43
Central Provinces	—1'96	+4'00
Berar	—6'06	+1'17
Bombay	—4'89	+1'39
Madras	—0'57	+3'43
Burma	+10'99	—1'01

The cold weather rains of 1885-86 commenced unusually early in December 1885; Northern, Western and Central India received a very unusual and exceptionally heavy burst of rain from the 12th to the 19th. This was apparently due to the existence for some days of a stationary depression in Guzerat, and was hence the result of very different conditions from those which generally give general rain in North-Western India in the cold weather.

The following were the chief meteorological conditions which probably influenced the character and distribution of the cold weather storms and rainfall :—

1st.—The very unusual character of the preceding south-west monsoon rains.

They were generally deficient in June and July, due chiefly to the weakness of the Bombay current in these months. They were, on the other hand, excessive in Northern and Western India during August, during which period the Bombay current was especially strong.

2nd.—The early withdrawal of the Bombay monsoon current from Upper India and its subsequent weakness and more rapid withdrawal than usual from the Arabian Sea.

3rd.—The earlier withdrawal of the Bengal current from Bengal and the north of the Bay. It continued steadily in the south and centre of the Bay until nearly the end of December, and hence Southern India and Ceylon received abundant rain from the retreating south-west monsoon current.

4th.—The pressure conditions at the end of the year differed little from the normal. Pressure was locally in excess in Upper India, but there was a slight but persistent deficiency of pressure in August, in South-West Rajputana and Lower Sind, which appears to have exercised an important influence during the cold weather.

5th.—Pressure was in slight defect over the whole of India.

6th.—The most marked feature was a considerable deficiency of pressure at the hill stations in the North-Western Himalayas as compared with the neighbouring plain stations and an excess at the hill stations in the Central and Eastern Himalayas.

MONTH.	VERTICAL PRESSURE ANOMALY.				
	Leh minus Lahore.	Quetta minus Jacobabad.	Murree minus Peshawar.	Ranikhet minus Lucknow.	Darjeeling minus Dhulel.
September 1885	—'030	+ '016	—'007	—'031	—'005
October "	+ '015	+ '016	—'030	+ '010	+ '014
November "	+ '028	+ '033	—'074	+ '006	—'014
December "	—'021	+ '015	—'003	+ '008	—'009
January 1886	—'033	—'019	—'013	+ '006	+ '037
February "	—'094	—'008	—'033	—'002	+ '011
March "	—'073	—'023	+ '005	—'002	+ '026

The preceding statement shows such great irregularities and discrepancies as to suggest that the observations of several of the hill stations at this period were very carelessly taken. The data indicate that there was apparently a considerable deficiency of pressure at the hill stations in the Western Himalayas and a slight excess in the Eastern Himalayas.

Chief features of the meteorology of the cold weather period, 1885-86.—

The cold weather of 1885-86 was on the whole somewhat more disturbed than usual. In January the rainfall was very considerably above the normal in the Punjab and slightly above it in the hill districts and adjacent plain districts of the North-Western Province. There were three disturbances or periods of rainfall during the month, *viz.* the 3rd and 4th, the 13th and 14th, and from the 18th to 22nd. The first two were slight local disturbances, and the third was a well-marked cyclonic cold weather storm, which gave a heavy fall of snow in the Afghan mountain districts and the Western Himalayas. February was a dry month, and the precipitation of the month occurred chiefly in the Western Himalayas. There were four periods of slight disturbance, *viz.* the 1st, the 5th to 9th, the 15th to the 17th, and the 26th to the 28th. A very heavy fall of snow is reported to

have been received in the Afghan mountain districts during the third period of disturbance. The depth of the snowfall on the Safed Koh was estimated at 10 to 15 feet.

The month of March was more disturbed than usual. There were three periods of disturbance, *viz.* from the 6th to the 11th, the 17th and 18th, and from the 25th to the end of the month. The first was a well marked cyclonic cold weather storm, which gave heavy rain in the plains and moderate snow in the hills. The two last were feeble disturbances which chiefly affected the hill districts and North Punjab.

April was a very dry month, but appears to have been very disturbed in some parts of the Western Himalayas. A great snowstorm is said to have occurred on the Rotang pass, and snow fell on ten days in Lahoul, and the weather was very cold and unseasonable.

The following gives a statement of the variation of the rainfall of the period from the 1st December 1885 to the 31st March 1886 from the normal :—

PROVINCE.	Variation from normal of average actual rainfall of period, 1st December 1885 to 31st March 1886.
	Inches.
Punjab	+2.92
Rajputana	+0.11
Central India	+2.83
North-Western Provinces and Oudh	+2.27
Bengal	+0.96
Assam	—1.22
Central Provinces	+2.93
Berar	+4.10

The preceding statement shows that the cold weather rainfall was in excess over Northern and Central India. The excess was exceptionally large relatively to the normal in Berar and the Central Provinces. It was also large in the Punjab, North-Western Provinces and Central India.

Storms of the cold weather period, 1885-86.—The following gives an account of the more important storms of this period the tracks of two of which are given in Plate LVII. They are the storm of the 15th to the 22nd January, the disturbance of the 14th to the 18th February, and the storm of the 6th to 12th March.

I. Disturbance of the 18th to 28th January 1886.—Pressure increased over the whole of India on the 16th and 17th, and was above the normal on the morning of the 18th over the whole of Northern and Central India except Sind, where there was a moderate deficiency apparently due to the formation or appearance of a very slight disturbance in Baluchistan. Skies clouded over in the Punjab, Sind and Rajputana on the 17th, and snow or rain fell on that day at Pishin, Quetta and Khelat in Baluchistan.

The following gives observations at Quetta and the Sind observatories for 10 A.M. of the 17th :—

STATION.	PRESSURE			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity, previous 24 hours.	
	"	"	"	"	"	"
Quetta	?	+010	-079	W	8	10
Kurrachee	29.996	-006	-085	NN-E	15	2
Hyderabad	971	-003	-175	N	5	5
Jacobabad	30.088	+013	-026	NN-W	2	7
Mooltan	148	+068	+019	N-E	2	10

Pressure was more or less above the normal in the Punjab and Rajputana, but was below it to a moderate extent in Baluchistan and Sind. The barometric movements in India during the previous 48 hours were small and somewhat irregular. Hence this disturbance was not preceded by a large and general fall of the barometer over India, which is the usual rule.

18th January.—The following gives the observations at the same stations on the morning of the 18th :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity, previous 24 hours.	
	"	"	"	"	"	"
Quetta	?	-016	-095	W	5	10
Jacobabad	30.031	-057	-083	Calm	4	10
Hyderabad	29.964	-007	-182	N	17	2
Kurrachee	29.970	-026	-111	EN-E	17	6

These observations show that a very shallow depression had formed in Sind or Baluchistan, but the winds in neither area gave any indication of cyclonic movement in the lower air strata. Skies were overcast over the whole of the Punjab, and rain was commencing in the northern districts. It may also be noted that the mean temperature was considerably above the normal in Northern India and that the aqueous vapour pressure had increased slightly at nearly all stations. The 4 P.M. observations show that the barometer began to fall rapidly in the North Punjab during the day, and that winds were increasing rapidly in force at Quetta and Murree.

19th January.—In consequence of these barometric changes in the Punjab, which continued during the night of the 18th, a deep depression covered the North Punjab

on the morning of the 19th. The following observations indicate its character and position:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Leh	?	—'212	?	Calm	1	10
Murree	?	—'346	—'261	S-E	8 ^p	10
Dera Ismail Khan	29'746	—'392	—'371	N-W	4	10
Peshawar	'767	—'457	—'362	WS-W	4	10
Mooltan	'827	—'302	—'302	W	3	10
Lahore	'828	—'277	—'266	ES-E	7	10
Rawalpindi	'841	—'342	—'296	S-E	2	10

Winds were feeble in the Punjab, but they indicated a fairly regular cyclonic circulation about a centre in the North Punjab. The winds at Murree were even lighter relatively to the normal than at the plain stations. If the wind amount at that station be correctly given it establishes that the air movement accompanying the rapid fall of pressure in the lower strata (up to 7,000 or 8,000 feet at least) was not horizontal, and was hence mainly vertical, and either ascensional or expansional.

General and moderately heavy rain had fallen over the whole of the Punjab, and showers in Rajputana and the north-western districts of the North-Western Provinces. In the Punjab 15 out of the 35 stations reporting rainfall to the Meteorological Office had falls exceeding one inch. The largest amounts recorded were —

	Inches.		Inches.
Murree Observatory	2'22	Kilba	2'60
Murree (Kutcherry)	6'00	Peshawar (Kutcherry)	2'30

The rainfall measurement at the Murree kutcherry is almost certainly exaggerated and probably due to erroneous measurement of snowfall.

The primary disturbance which was in Sind on the 18th appears to have moved into West Rajputana on the 19th. The indications of its existence were obscured by the large depression in the North Punjab, but the following observations appear to establish its continued existence:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Hyderabad	29'905	—'058	—'240	N-E	4	0
Bhuj	'928	—'023	—'145	N-W	10	6
Deesa	'938	—'042	—'123	SS-W	14	10
Pachpadra	'922 ?	—'077	?	WS-W	10	0
Bickaneer	'938 ?	—'079	?	S-E	8	10
Jeypore	'949	—'122	—'162	SS-E	6	10

The barometric observations at Pachpadra and Bickaneer were, it should be noted, vitiated by frequent large errors at this period. The readings given in the table are corrected to their most probable values.

The observations show that an independent cyclonic circulation (very feeble) was established in this area, and that the centre of the circulation and the depression was to the west of Bickaneer and north of Pachpadra.

The 4 P.M. observations of the same day indicate that the primary depression was moving eastwards, and that the secondary depression in the Punjab was practically unchanged in position, but that it was beginning to fill up.

The greatest deficiency at 4 P.M. as at 10 A.M. was registered at Peshawar ($-0.302''$) and Dera Ismail Khan ($-0.297''$). The air motion was very irregular. Dera Ismail Khan, Rawalpindi and Jacobabad reported calms at that hour, whilst at Murree, Chakrata and Ranikhet the winds were from three to five times their normal strength.

A rapid decrease of temperature exceeding 10° at several stations had occurred during the previous 24 hours. Humidity was decreasing rapidly in Sind with the extension of north-west winds across that area into Rajputana.

20th January.—A rapid recovery of pressure had occurred over the Punjab, and the secondary depression was filling up. The following gives data for stations in the North Punjab:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M., reduced to sea-level and gravity at Lat. 45° .	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Leh	?	-0.124	?	SS-W	1	10
Murree	?	$+0.105$	-0.156	S-E	27	10
Peshawar	30.040	$+0.273$	-0.089	W	3	10
Dera Ismail Khan	29.979	$+0.233$	-0.138	N	2	8
Rawalpindi	30.000	$+0.159$	-0.137	NN-E	5	10
Sialkot	29.987	$+0.145$	-0.117	N-E	6	6
Lahore	29.961	$+0.133$	-0.133	S	5	10

The barometric observations in the North Punjab show that the barometer had risen very rapidly over the whole area and that there was a moderate but nearly uniform deficiency slightly exceeding a tenth of an inch over the whole province. It is hence evident that the changes were the reverse of those which had previously occurred, and that the depression had not been transferred from its previous position in the North Punjab. The wind indications confirm the barometric observations, and the whole evidence hence establishes that the depression was filling up in the area in which it formed.

The position of the primary depression is given by the following observations:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M., reduced to sea-level and gravity at Lat. 45° .	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Indore	29.932	$+0.015$	-0.109	N	4	5
Saugor	940	-0.045	-0.145	S-W	2	2
Jhansi	939	-0.028	-0.136	ES-E	?	7
Agra	942	-0.001	-0.154	E	5	10

These observations show that a shallow depression lay over Central India, the centre of which was probably a little south of Jhansi. It was, however, of little importance, and skies were clear or lightly clouded in this depression.

Temperature had increased very rapidly in the eastern districts of the North-Western Provinces and was diminishing fast in North-Western India. A rapid decrease in the amount of aqueous vapour in the air had occurred in Sind in consequence of the setting in of north-west winds. Skies had cleared in Sind and were clearing in the Punjab, but were more or less clouded in the North-Western Provinces.

Heavy snow had fallen in the Punjab Himalayas, and light to moderate rain in the eastern districts of the Punjab and the greater part of the North-Western Provinces.

The disturbance filled up and disappeared during the next 24 hours.

This disturbance hence consisted of a very slight and ill-defined primary depression and of a deep secondary depression in the Punjab. The track of the former is not given in the storm chart track of the month, as it is not possible to fix it with approximate accuracy.

The following gives a statement of the rainfall due to the storm :—

DISTRICT.	ACTUAL AVERAGE RAINFALL.			Total.
	18th.	19th.	20th.	
Punjab	Inch. 0'13	Inch. 0'58	Inch. 0'23	Inch. 0'94
North-Western Provinces	0'01	0'14	0'37	0'52
Rajputana	0'03	0'02	0'01	0'06
Central India	Nil	Nil	Nil	Nil

A disturbance probably similar in character, but on a small scale, occurred on the 22nd and 23rd January. Pressure fell at Quetta and in Upper Sind on the 20th, indicating slight disturbance. A much more rapid fall followed in the North Punjab on the 22nd, and on the morning of the 23rd a shallow depression covered that area. Light showers fell in the North Punjab and hill districts. The depression filled up during the day. Fine clear weather continued till the 30th.

A second small disturbance formed in Upper Sind on the 30th. It advanced eastwards into Central Rajputana on the 31st. Light showers fell in the North and West Punjab during the preceding 24 hours. It passed into the western districts of the North-Western Provinces on the 1st February, and disappeared during the day. Moderately heavy rain was received at the foot of the Punjab hills and snow in the hill districts. The following largest amounts were reported :—

DATE.	Station.	Amount.
31st January	Kilba	Inches. 3'60
" "	Murree	3'60
1st February	Kilba	3'00
" "	Murree	1'20
" "	Chamba	1'36

The precipitation was hence chiefly in the hill districts. The storm and depression was very small, and hence is not included in the list.

II. Disturbance of the 14th to the 18th February 1886.—This was a remarkable storm, and charts are given (*vide* Plates LXIII and LXIV) illustrating its phases. Strongly marked anti-cyclonic conditions obtained in Northern India from the 1st to the 12th of February, on the morning of which day pressure ranged from 30°30" in the Indus Valley to 30°00" in Southern India and the south of the Bay, and was 10" to 20" above the normal. Pressure then began to give way, decreasing most rapidly on the 12th and 13th in West Rajputana, and a shallow depression formed in that area.

The following gives data for the area of depression on the morning of the 14th:—

STATION.	PRESSURE.			WIND.		Cloud at 8 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Quetta	?	—'102	—'018	SS-W	5	10
Jacobabad	30°059	—'090	+ '011	EN-E	2	10
Hyderabad	'054	—'111	—'030	N	2	6
Pachpadra	'097	—'128	?	S-E	...	6
Bickaneer	'081	—'134	?	EN-E	...	8
Ajmere	'080	—'086	+ '052	N-E	8	2

There was some slight disturbance previously in the area to the west of Sind, as Bushire recorded 1°05 inches of rain on the 12th, and Peshin, Quetta and Khelat registered moderate amounts on the 14th. This slight disturbance was apparently transmitted eastwards and drifted into the area of low pressure in Rajputana on the 15th. This depression then received a slight development.

The following observations indicate its position and character on the 15th:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Mount Abu	?	—'122	—'064	S-W	5	0
Deesa	29°876	—'131	—'133	SS-E	6	1
Pachpadra	'853	—'196	?	Calm	0	0
Ajmere	'916	—'164	—'112	S-E	8	2
Bickaneer	'912	—'122	?	Calm	1	5
Jacobabad	'972	—'087	—'076	NN-E	2	5
Hyderabad	'957	—'097	—'127	N	2	0

The barometer had continued to fall over the whole of India on the 14th, but on the 15th a remarkably rapid fall occurred in the Punjab, accompanying the formation of a deep secondary depression in the North Punjab.

16th February.—The following data show the position of the secondary depression on the morning of the 16th:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Murree	"	"	"	S-E	26	10
Peshawar	29'616	—'351	—'408	NN-W	5	10
Rawalpindi	29'650	—'360	—'440	S-W	3	10
Dera Ismail Khan	29'656	—'365	—'411	W	4	4
Lahore	29'629	—'328	—'400	S-E	4	2
Sialkot	29'710	—'325	—'406	ES-E	2	6

These observations indicate that a deep depression had formed in the Punjab and that a well marked cyclonic circulation obtained over the depression. The fall of the barometer was absolutely as large at Murree as at the plains stations of Rawalpindi and Peshawar, and the wind direction at Murree showed that the cyclonic circulation at the level of that station was practically identical in character with that at the level of the plains, but was very much stronger. The centre of the cyclonic circulation was apparently between Murree and Peshawar or amongst the North Punjab hills. Light to moderate showers had fallen in the North Punjab during the previous 24 hours. The Punjab rainfall returns give no indication of heavy rainfall such as would naturally be associated with so large a fall of the barometer. The snowfall reports, however, show that exceptionally heavy snowfall was received during the storm in the mountains in North Afghanistan, and hence probably in those to the north of the Peshawar and Hazara districts. It is, for example, stated that an unusually heavy fall of snow occurred on the 15th and 16th February in North-East Afghanistan. The Assistant Commissioner of Thall estimated the fall at from 10 to 15 feet in the Safed Koh Mountains, 3 feet in the Tirah Hills and from 1½ to 2 feet in the Kurrum Valley. It was also reported that 3 feet of snow fell at Lundi Kotal and 2 feet at Ali Masjid from the 15th to the 17th.

The primary disturbance was now almost entirely obscured by the secondary depression. A reference to the chart of the day (Plate LXIV) will show a peculiar bend or downward curving of the isobars over Central India, which was almost certainly due to the primary depression. If this be the case, it had marched east-south-east into the area defined by the following stations:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Saugor	29'879	"	"	S	8	2
Jhansi	29'873	—'057	—'107	S-E	7	0
Indore	29'853	—'084 ?	—'142	SS-W	5	0
Hoshangabad	29'919	+ '007	—'126	Calm	2	0

Skies were clouded in this area and showers had fallen at several stations in Central India and the Saugor and Jubbulpore districts of the Central Provinces. The largest amount was '6 inch at Saugor.

17th February.—A very rapid increase of pressure had taken place in Upper India during the previous 24 hours, which completely filled up the secondary depression. The following gives data for stations in the North Punjab:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Murree	?	+ '314	— '094	Calm	23	10
Rawalpindi	30'092	+ '442	+ '031	SS-W	3	0
Peshawar	30'100	+ '484	+ '044	W	6	0
Dera Ismail Khan	30'112	+ '456	+ '056	N-W	3	2
Lahore	30'031	+ '402	— '004	S-E	6	10

Skies had almost cleared in the Punjab, and light winds and calms prevailed. North to north-westerly winds prevailed over North-Western India and were reducing temperature and humidity very rapidly.

The primary depression, although shallow, was very distinctly marked. It now covered Chota Nagpur and South Bihar. The following observations define its position:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Sambalpur	29'940	+ '013	?	S-W	1	2
Hazaribagh	'936	— '008	— '038	SS-W	8	10
Gaya	'927	— '041	— '085	E	2	4
Benares	'945	— '019	— '062	WS-W	7	0

Light showers had fallen in Bihar, chiefly in the northern districts. The largest amount registered was '38 inch at Monghyr.

18th February.—A further rise of the barometer had occurred in North-Western India and strongly marked anti-cyclonic conditions now obtained in that area. The

primary disturbance and depression had advanced eastwards during the previous 24 hours into the area defined by the following stations:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Berhampore	30.011	—0.02	—0.008	NN-W	2	8
Jessore	29.980	—0.029	0	N-W	8	7
Dacca	.977	—0.033	—0.011	S-W	3	10
Silchar	.999	—0.034	—0.014	E	3	2
Dhubri	.984	—0.050	—0.033	Calm	3	0

A fairly well marked but feeble cyclonic circulation prevailed in this area. Skies were partially clouded and showers had fallen in North and Central Bengal and Assam, but the amounts were small. The largest were .65 inch at Maldah and .32 inch at Dhubri. The depression passed eastwards during the day, probably into Upper Burma. Pressure increased rather rapidly in North-Eastern India during the next 24 hours, and fine clear weather set in.

The disturbance hence consisted of a shallow depression, which advanced eastward across Northern India, and of a very deep depression, which formed very rapidly in the North Punjab, and broke up with even greater rapidity.

The following gives a statement of the rainfall in Northern India due to this storm:—

DISTRICT.	RAINFALL OF 24 HOURS PRECEDING 6 A.M. OF FEBRUARY.				Total of period.
	15th.	16th.	17th.	18th.	
Punjab	Inch. 0.01	Inch. 0.04	Inch. 0.14	Inch. Nil	Inch. 0.19
Rajputana	Nil	Nil	Nil	Nil	Nil
Central India	0.01	0.05	Nil	Nil	0.06
North-Western Provinces	0.01	0.03	0.05	0.01	0.10
Bihar and Chota Nagpur	Nil	0.01	0.05	0.03	0.09
Bengal and Orissa	Nil	Nil	0.02	0.02	0.04
Assam	Nil	Nil	Nil	0.04	0.04

The following gives the approximate position of the centre of the primary depression at 10 A.M. of each day from the 15th to the 18th:—

DATE.	POSITION OF CENTRE.		Distance travelled in 24 hours.
	Lat. N.	Long. E.	
15th February	25½	72½	...
16th "	25	78½	380 miles.
17th "	24½	84½	350 "
18th "	24	90	

Its mean rate of motion from the 15th to 18th was about 360 miles per diem, or 15 miles per hour.

III. Disturbance of the 6th to the 12th March 1885.—This disturbance apparently formed in Baluchistan, as the Bushire observations indicate that no depression passed through Persia in the last week of February or the first week of March.

6th March.—The following observations taken at 10 A.M. of the 6th at Quetta and the Sind stations show the character and position of the disturbance at that hour:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Quetta	P	—138	—178	SS-W	7	8
Jacobabad	29 885	—107	—030	NN-E	6	10
Hyderabad	864	—102	—096	SS-E	5	0
Kurrachee	852	—121	—085	SS-E	9	10

The following gives the pressure changes at these stations from the 3rd to the 6th:—

STATION.	CHANGE IN 24 HOURS PRECEDING 10 A.M. OF			
	3rd.	4th.	5th.	6th.
Bushire	+065	—123	—002	+056
Quetta	+042	+063	—143	—138
Jacobabad	+051	+055	—080	—107
Kurrachee	+047	+039	—057	—121

These observations show clearly that a depression appeared in Baluchistan on the 5th and 6th, and that the barometer in the centre was probably at least two-tenths below the normal on the 6th.

Skies were more or less clouded over the whole of Northern India and were overcast in Baluchistan, Sind and the Punjab. Moderate rain had fallen in Baluchistan, Sind and the western districts of the Punjab, the largest amount being 1·73 inch at Quetta.

7th March.—The 10 A.M. observations of this day show that the depression was transferred to West Rajputana.

The following define its position:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Quetta	?	+070	—108	Calm	4	4
Deesa	29 822	—055	—105	WN-W	10	2
Ajmere	855	—050	—053	Calm	8	8
Bickaneer	835	?	?	SS-W	1	2
Pachpadra	814	?	?	Calm	...	0
Jacobabad	890	+005	—025	N-W	2	0
Mount Abu	P	—103	—118	S-W	8	7

The central depression was hence probably to the north-west of Pachpadra. The fall of the barometer was much larger at Mount Abu than at either of these stations. The total fall at Quetta had also been considerably larger than at Jacobabad, and it is hence almost certain this was a general feature of this depression throughout. Skies were now clear in Sind and were only partially clouded in Rajputana, but were overcast in the Punjab and the Punjab hills. General moderate rain had fallen during the previous 24 hours in the Punjab and western districts of the North-Western Provinces, and local thundershowers in Rajputana, Central India and the Central Provinces.

The largest amounts were registered at Amritsar and other stations at the foot of the Punjab hills and not at the hill stations. No rain fell at Murree.

Temperature was very largely below the normal in Northern India, chiefly in consequence of the large amount of cloud.

8th March.—The depression had advanced into Central Rajputana, as is shown by the following observations :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Mount Abu	P	—'004	—'122	N	6	2
Deesa	29'82	+ '004	—'098	N-NE	9	2
Saugor	'811	—'046	—'078	S-W	7	2
Jhansi	'829	—'054	—'070	S-W	?	5
Jeypore	'83	—'019	—'084	ES-E	12	6
Jamere	'83	—'018	—'071	Calm	8	5

The centre of this depression was in Lat. 26° N. and Long. 75½° E., where the barometer was nearly two-tenths of an inch below the normal. A fairly regular cyclonic circulation continued in the depression, but the winds were nowhere strong. Skies were overcast in the Punjab, the North-Western Provinces and Bihar, and partially clouded in Rajputana, Central India, the Central Provinces and Bengal. General rain had fallen during the previous 24 hours in the Punjab (except the western districts), the North-Western Provinces, and some light local thundershowers in Rajputana, Central India and the Central Provinces. An independent disturbance was giving thunderstorms in Bengal. The largest amounts were recorded in the districts at the foot of the Punjab Himalayas. The fall equalled or exceeded 2 inches at Jhelam, Gujrat and Gurdaspur.

9th March.—The disturbance had drifted eastwards at the same rate as hitherto, and the central depression was passing through Bundelkhand at 10 A.M., as is shown by the following observations :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Jubbulpore	29'865	+ '004	—'040	N-W	4	1
Sutna	'826	+ '012	—'076	SS-W	4	2
Allahabad	'898	+ '007	—'053	E	9	4
Nowgong	'855	+ '045	—'104	NN-W	2	3

A general increase of pressure ranging from '05" in Bengal to '12" in the West Punjab had occurred outside the area of depression during the past 24 hours in Northern India, and hence a slight rise of the barometer had occurred in the area through which the depression was passing. Skies were now clear in the West and North Punjab, but were more or less heavily clouded in Northern India. General rain had again fallen in the Punjab excepting the western districts, and in the North-Western Provinces and Oudh, and a few light local showers in Rajputana and Central India of no importance. Easterly winds prevailed in the Gangetic plain, but in Lower Bengal northerly winds continued, and hence were not dependent upon the depression in Bundelkhand. The local disturbance in Bengal had given numerous thunderstorms with moderate rain, chiefly in South Bengal.

10th March.—A rapid increase of pressure had occurred during the previous 24 hours over the whole of India. It was greatest in the North-Western Provinces, and at several stations amounted to two-tenths of an inch. In consequence of this change the depression was very faintly indicated by the wind directions. It was now passing through Chota Nagpur and South Bihar, as is shown by the following:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Hazaribagh	30'066	+ '091	+ '202	SS-W	11	0
Gaya	30'056	+ '094	+ '212	E	4	0

Notwithstanding the rapid increase of pressure, skies were still more or less heavily clouded in Northern India. They had completely cleared in Rajputana, Central India and the Central Provinces.

Light showers had fallen in the eastern and southern districts of the Punjab and over the greater part of the North-Western Provinces (excepting the districts bordering on Rajputana), and moderate general rain had fallen in Bihar and Chota Nagpur. Practically no rain had fallen in South Bengal and the slight disturbance in that area was hence passing away.

11th March.—The barometer continued to rise over the whole of Northern India excepting Bengal, through which the slight disturbance was passing. The following observations appear to locate its position in about Latitude 24° N. and Longitude 91° E. :—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Jessore	30'063	— '014	+ '127	W	6	1
Dacca	'056	— '045	+ '160	S-W	2	1
Dhubri	'069	— '066	+ '164	Calm	.5	0
Berhampore	'072	— '046	+ '142	N	2	0

Skies had cleared over the whole of Northern India, and only a few local showers of little importance had fallen during the previous 24 hours. With the clearing of the skies

a rapid increase of temperature ranging from 2° in Bengal to 6° in the North-Western Provinces had occurred.

12th March.—The observations appear to indicate that the disturbance passed across East Bengal into Upper Burma on the evening of the 11th, but they do not enable its position to be defined.

The storm of the 6th to 12th March was hence, when judged by the depression of the barometer below the normal, of very feeble intensity. It was, however, very persistent and drifted across Northern India unchanged in character at a nearly uniform rate of about 300 miles daily. It gave a heavy and prolonged fall of rain to the whole of Northern India from the Punjab to Bihar.

The following gives approximately the position of the centre of the shallow depression day by day :—

DATE.	POSITION.		Distance passed over in 24 hours.
	Latitude. N.	Longitude. E.	
6th March	28	66½	Miles. ...
7th "	27	71	300
8th "	26	75	270
9th "	25	80½	340
10th "	24½	84½	280
11th "	24½	93	400
12th "	Upper Burma		360 ?

It hence travelled in an east by south track. Considering that it traversed the whole breadth of India practically unchanged in direction, it is possible that it originated as far west of India at least as Persia, but, as already stated, there is no satisfactory evidence afforded by the Bushire observations of its having crossed through Central Persia.

The following gives a brief statement of the average rainfall day by day during the storm in different provinces of Northern and Central India :—

DISTRICT.	AVERAGE RAINFALL IN 24 HOURS PRECEDING 5 P.M. OF						Total 6th to 11th.
	6th.	7th.	8th.	9th.	10th.	11th.	
Baluchistan	Inches. 0'52	Inches. 0'12	Inches. 0'06	Inches. Nil	Inches. Nil	Inches. Nil	Inches. 0'70
Sind	0'19	0'01	0'01	0'01	Nil	Nil	0'22
Punjab	0'14	0'46	0'71	0'30	0'13	0'01	1'75
Rajputana	0'03	0'02	Nil	0'07	Nil	Nil	0'12
Central India	Nil	0'03	0'09	0'15	Nil	Nil	0'27
North-Western Provinces	Nil	0'07	0'32	0'61	0'18	Nil	1'18
Oudh	Nil	Nil	0'13	0'46	0'53	Nil	1'12
Central Provinces	Nil	0'11	0'09	0'14	0'01	0'01	0'36
Bihar	Nil	Nil	0'03	0'09	0'35	Nil	0'47

As has already been stated, the rainfall accompanying the storm was very small in amount in the central depression when passing through Rajputana and Central India. The rainfall was chiefly precipitated in Northern India in the districts of the Punjab, the North-Western Provinces, and Bihar near the hills, and was not large in amount at the hill stations. Hence, probably, the storm gave little snow in the higher elevations. The temperature changes accompanying the storm confirm this, as they were evidently due to two causes, *viz.* the effect of cloud in diminishing temperature in the hot weather and the effect of rainfall.

The following gives examples of the temperature changes during the storm :—

STATION,	CHANGE OF MEAN TEMPERATURE IN 24 HOURS PRECEDING 10 A.M. OF						
	5th.	6th.	7th.	8th.	9th.	10th.	11th.
Jacobabad	0	0	0	0	0	0	7
Lahore	+3°0	-5°3	-7°5	+7°3	-0°5	+2°2	+5°8
Jeypore	-0°5	+6°8	-7°8	-2°5	0	0	+3°8
Jeypore	-2°5	+1°0	-4°2	+2°0	-4°5	-2°5	+6°2
Allahabad	+0°1	-4°8	+2°2	+1°7	-3°1	-1°2	-2°9
Patna	+1°5	-7°0	+2°5	-2°0	+0°5	+1°0	-1°2

The storm was hence of the usual cold weather type. It drifted in the same general direction, and although of small intensity was remarkably persistent. Its chief features were, first, its somewhat slower rate than that of the corresponding storms of January and February; second, the precipitation accompanying it was, relatively to the total amount, small in the hill districts, and hence perhaps the reason that it did not give rise to a secondary depression.

1886-87.

Chief abnormal features of the meteorology of India in 1886.—The general character of the weather of the preceding year will be found fully discussed in the Annual Report for 1886. It will be sufficient to state the more remarkable features :—

1st.—The cold weather months of January and February were remarkably dry over the whole of India (except in the Punjab, which received normal rain).

2nd.—During the hot weather period March was marked by excessive rain and April by very great dryness. The month of May was very disturbed, and both North-Eastern and Southern India and the Deccan received excessive rain.

3rd.—The rains commenced about a week later than usual on the Bombay coast and were normal in Bengal. Abundant rain fell in nearly every part of India in June and July. A break in the rains prevailed for some time in the beginning of August, and the Bombay current was weak throughout that month. North-Eastern and Southern India received abundant rain, and North-Western and Western India very deficient rain in that month. In September the distribution of rain was very similar to that of August, North-Eastern and Southern India obtaining normal to excessive rain, and North-Western, Western and Central India very deficient rainfall.

4th.—In the month of October rain in large amounts fell in almost every part of India, except Assam, Burma, East Bengal and South Madras. The rainfall was excessive over the north and centre of the Peninsula. Pressure conditions in November were similar to those of October and very abnormal but less marked. Rainfall was in excess in Orissa, North Madras and Pegu, but was generally in defect elsewhere. Rainfall in December was distributed irregularly. It was in excess in the north of the Peninsula and was considerably in defect in Madras and Ceylon.

Hence, as in 1889, the abundant rainfall during a part of the south-west monsoon period was followed by very irregularly distributed and deficient rainfall in Madras. The rains ceased in the second week of the month of December, and hence earlier than usual. There were no very marked features in the pressure distribution of December.

The following gives a comparative statement of the variation of the rainfall from the normal in the south-west monsoon and retreating south-west monsoon periods:—

DISTRICT.	VARIATION FROM NORMAL OF AVERAGE ACTUAL RAINFALL.			
	June to September 1886.	Variation expressed as percentage.	October to December 1886.	Variation expressed as percentage.
	Inches.		Inches.	
Western Himalayas	— 3'85	— 9	— 0'16	— 5
Punjab Plains	+ 1'07	+ 7	+ 0'26	+ 21
North-Western Provinces and Oudh	+ 4'03	+ 12	+ 1'47	+ 80
Rajputana	— 0'63	— 3	+ 0'16	+ 25
Central India States	— 6'66	— 17	+ 4'48	+ 196
Bihar	+ 13'20	+ 36	+ 4'04	+ 115
Western Bengal and Chota Nagpur	+ 2'44	+ 6	+ 2'78	+ 65
Lower Bengal	+ 4'33	+ 9	— 1'66	— 31
Eastern Himalayas	+ 5'46	+ 5	— 2'71	— 42
Assam and Eastern Bengal	+ 9'93	+ 12	— 2'93	— 41
Orissa and Northern Circars	+ 4'06	+ 11	+ 6'65	+ 78
Central Provinces, South	— 9'69	— 22	+ 2'98	+ 101
Berar and Khandesh	+ 3'34	+ 10	+ 4'75	+ 119
Guzerat	+ 2'04	+ 6	+ 1'28	+ 109
Sind and Cutch	— 0'57	— 7	— 0'19	— 53
North Deccan	— 2'07	— 10	+ 4'69	+ 74
Konkan and Ghats	+ 4'94	+ 4	+ 5'33	+ 91
Malabar and Ghats	— 18'02	— 20	+ 0'38	+ 3
Hyderabad	+ 4'46	+ 17	+ 3'06	+ 61
Ceded Districts and Mysore	+ 5'45	+ 35	+ 0'84	+ 10
Carnatic	+ 6'20	+ 50	— 5'10	— 28

DISTRICT.	VARIATION FROM NORMAL OF AVERAGE ACTUAL RAINFALL.			
	June to September 1885.	Variation expressed as percentage.	October to December 1886.	Variation expressed as percentage.
	Inches.		Inches.	
Nilgiris	+ 4·89	+ 32	— 8·46	— 38
Ceylon	+ 5·67	+ 29	— 7·54	— 25
Arakan	+ 0·03	0	— 0·82	— 7
Pegu	— 2·96	— 5	— 0·27	— 3
Tenasserim	+ 0·15	0	+ 0·55	+ 4
Bay Islands	— 5·69	— 10	+ 8·03	+ 25

The following were the conditions probably most influential in determining the character and distribution of the cold weather rains :—

- 1st.—The south-west monsoon rainfall was unusually abundant and very favourably distributed. It was largely in excess in Madras and North-Eastern India. There was a moderate deficiency in Central India and the greater part of the Central Provinces.
- 2nd.—The rainfall of the retreating south-west monsoon rainfall was very irregularly and abnormally distributed. The western and northern districts of the Peninsula received larger amounts than usual, and the Carnatic and Ceylon had amounts very considerably below the normal.
- 3rd.—The mean pressure condition of the Indian area agreed approximately with the normal. Locally, pressure was in excess in the submontane districts of Northern India and in the greater part of the Peninsula. Between these two areas of slightly increased pressure was a belt of deficient pressure relatively to the normal conditions. This deficiency was shown most strongly by the observations at Ajmere, Raipur, Sambalpur and Gopalpur.
- 4th.—The following statement gives the vertical pressure anomalies of pairs of stations, consisting of a hill station and the nearest plain stations comparable with it.

The cold weather rains of 1886-87 were marked by a fairly regular monthly oscillatory fluctuation. The month of January was characterised by a succession of storms in Northern India, the chief features of which were excessive snowfall in the Eastern Himalayan area and heavier rainfall than usual over the whole of North-Eastern India. This rainfall was, on the whole, most excessive in Assam and Bengal, or in the plain districts immediately adjacent to the hill districts of heaviest snowfall.

February was an unusually dry month. The temperature in Northern India was considerably below the average of the season for some time after the heavy rain and snowfall of January, but it increased with unusual rapidity in the third and fourth weeks of the month. The disturbing effect of the rapid accumulation of heat in the lower atmo-

spheric strata was shown in the month of March by the occurrence of several unusually vigorous series of thunderstorms in Bengal, Lower Burma and the plain districts in the neighbourhood of the hills in Northern India. Bengal, Bihar, Lower Burma, Tenasserim and the Carnatic received larger amounts of rain during the month than usual. The rainfall of the month was generally much below the average in Upper India. There was hence the same general relation between the amount and intensity of disturbance and the rainfall of North-Eastern and North-Western India during this month, as in January, excess in the former area accompanying deficiency in the latter area.

The following statement gives comparative data of the rainfall of the cold weather season of 1886-87 :—

DISTRICT.	VARIATION FROM NORMAL OF AVERAGE ACTUAL RAINFALL.	
	1st December 1886 to 31st March 1887.	Variation expressed as percentage.
Western Himalayas	Inches. —2'19	— 21
Punjab Plains	—2'21	— 58
North-Western Provinces and Oudh	—0'17	— 8
Rajputana	—0'28	— 42
Central India States	+1'62	+ 98
Bihar	+1'00	+ 60
West Bengal and Chota Nagpur	+0'23	+ 9
Lower Bengal	+1'54	+ 49
Eastern Himalayas	+1'86	+ 47
Assam and East Bengal	+2'95	+ 48
Orissa and Northern Circars	+0'39	+ 17
Central Provinces, South	—0'85	— 47
Berar and Khandesh	Nil	0
Guzerat	—0'22	— 85
Sind and Cutch	—0'13	— 19
North Deccan	+0'91	+105
Konkan and Ghats	—0'32	— 58
Malabar and Ghats	—1'39	— 61
Hyderabad	—0'67	— 58
Ceded Districts and Mysore	—0'67	— 53
Carnatic	—2'02	— 42
Nilgiris	—1'35	— 18
Ceylon	—5'79	— 32
Arakan	+2'76	+ 88
Pegu	—0'39	— 72
Tenasserim	+1'93	+ 99
Bay Islands	+2'67	+ 20

The following gives a history of the storms of the period. Two of these described below were of considerable importance and gave moderate to heavy rain. The first, that of the 10th to the 16th January, was very abnormal in character, and it is not possible to give its track in the storm track chart of the season. The only remaining disturbance, *viz.* that of the 17th to the 23rd January, was normal in character and advanced across the head of the peninsula, and its track is shown in the track chart of the season 1886-87, Plate LVIII.

The first disturbance of the cold weather of 1886-87 occurred during the period from the 22nd to the 29th of December. Showers of rain and snow fell in the hill districts of the Punjab and North-Western Provinces and in the northern and central districts of the Punjab. The total amounts were small and less than the normal of the month. The disturbance was so slight as not to justify its inclusion in the list of storms.

It has already been pointed out that the most important feature in the pressure distribution in December was the occurrence of a belt of slightly deficient pressure running across Northern India, separating higher pressure in the North Punjab from excessive pressure in the Peninsula. It was more marked in January than in December and was apparently greatest in a line connecting Ajmere, Sambalpur, Raipur and Gopalpur, but this seems somewhat doubtful in view of the character of the observations at two of these stations.

A very small disturbance originated in the Central Provinces on the 6th January. It gave light showers on that day in the Central Provinces and Central India. It was transferred eastwards and covered North and Central Bengal on the morning of the 8th. It gave very light showers in Bengal, Bihar and Chota Nagpur at this time and filled up during the next 24 hours. The largest reported rainfall was 1.16 inches at Calcutta during a thunderstorm. On the morning of the 9th conditions were fairly normal, although pressure was more uniform than usual and also slightly in defect. Skies had clouded over in Upper India and were overcast in Upper Sind and the Punjab but were clear in almost all other districts. The barometric movements were slight, except at Quetta where a rapid fall of nearly an eighth of an inch had occurred and rain was falling. Winds were light there and at Murree, and were irregular in direction in the plains of Northern India, although north-east winds on the whole predominated. This immediately preceded the appearance and formation of one of the more important disturbances of the cold weather of 1886-87.

Disturbance of the 10th to the 16th January.—Weather had been slightly disturbed with light showers over a large part of Northern India on the 7th, 8th and 9th. The disturbance became more pronounced on the 10th and following days.

10th January.—The barometric changes of the preceding 24 hours were extremely irregular. The barometer had risen rapidly in Bengal and the North-Western Provinces, whilst it had fallen slightly in the Peninsula. The changes in the Peninsula and Burma indicated that the barometer was beginning to rise generally in accordance with the ordinary oscillatory movement of the period. Pressure was falling slowly in the North Punjab and rapidly at the hill stations.

The baric differences were small in Northern India and no marked depression was shown by the chart of that day. Pressure was slightly in defect in the Punjab (most largely at Murree), but the chief feature was excessive pressure along the foot of the hills from Roorkee to Dhubri.

Winds were light and irregular in Upper India, normal in Bengal and somewhat irregular in the Deccan. Temperature was falling rapidly at the hill stations in Upper India. In consequence of the amount of cloud in Upper India the night temperature was largely above the normal in the plains, whilst the day temperature was diminished to a less extent, and hence the mean daily temperature had increased. The air was damper than usual in Upper India, but this was apparently due chiefly to the occurrence of rainfall in Upper India and in part to the setting in of easterly winds at many stations in the Gangetic plain, and thus transferring vapour from the damper easterly districts to the drier westerly districts of the Gangetic plain.

The following gives comparative temperature data for three hill stations and four plain stations:—

STATION.	VARIATION FROM NORMAL OF			Change of Mean temperature in past 24 hours.
	Maximum temperature.	Minimum temperature.	Mean temperature.	
Hill stations—	0	0	0	0
Murree	—10°8	—9°6	—10°2	—5°0
Simla	—7°9	—8°2	—8°1	—1°5
Chakrata	—4°4	—7°3	—5°9	—0°6
Plain stations—				
Peshawar	—8°1	+2°3	—2°9	—0°3
Sialkot	—5°7	+7°2	+0°8	+5°7
Lahore	—2°6	+4°6	+1°0	+7°0
Agra	—0°1	+6°8	+3°4	+6°0

Skies were overcast in the Punjab, the western districts of the North-Western Provinces and South Sind and were clear in other districts. The cloud area was hence very sharply defined and had extended to the southwards considerably during the previous 24 hours.

Rain had fallen in the Punjab and North-Western Provinces and snow in the hills, but the amounts were nowhere large—nowhere exceeding an inch in amount. The largest falls were:—

Quetta	Inch. .82
Peshin	.79
Dharmasla	.70

11th January.—The barometer had risen very rapidly during the previous 24 hours in the Punjab. This was apparently due to the cessation of rainfall on the evening of the 10th. This is further confirmed by the decrease in the cloud amount, more especially in the Punjab and the North-Western Provinces, data of which are given in the following table:—

DISTRICT.	AVERAGE CLOUD AMOUNT AT 10 A.M. OF		Change in previous 24 hours.
	10th January.	11th January.	
Punjab hills	10°0	8°5	—1°5
" plains	8°8	6°2	—2°6
Sind	4°0	7°7	+3°7
Rajputana	7°5	6°0	—1°5
North-Western Provinces hills	10°0	7°7	—2°3
" " plains	5°6	4°6	—1°0

Elsewhere the weather changes were small, but the barometer was generally rising, and pressure was almost everywhere above the normal. Pressure was highest on the West Punjab frontier and steepish gradients obtained in North-Western India.

Temperature had fallen rapidly in the hills and also in the area of clearing skies in the plains, including the Punjab, the North-Western Provinces and Rajputana.

The following gives temperature data in illustration :—

STATION.	VARIATION OF			Change in 24 hours in mean temperature.
	Maximum temperature from normal.	Minimum temperature from normal.	Mean temperature from normal.	
Hill Stations—				
Murree	—16·8	—11·6	—14·2	—5·0
Simla	—16·8	—6·2	—11·5	—4·3
Chakrata	—17·2	—6·2	—11·7	—6·2
Plain stations—				
Peshawar	—10·9	+ 4·9	—3·0	0
Lahore	—9·7	—0·4	—5·1	—5·7
Agra	—8·2	+ 3·8	—2·2	—5·2
Jeypore	—4·1	+ 3·8	—0·2	—3·0

Winds were irregular in the North-Western Provinces and Bihar and normal in Bengal and the Peninsula. Moderately strong north-east winds prevailed in the Punjab. There was partial cloud in the Punjab, Central India, the Central Provinces and the western districts of the North-Western Provinces, in all of which areas (except the Central Provinces) the skies were clearing. Skies were heavily clouded in the eastern districts of the North-Western Provinces, and were, on the other hand, clear in Bengal, Burma and Bombay.

The amount of aqueous vapour was, on the whole, decreasing in Upper India, although the changes were irregular. It was increasing rather rapidly in the eastern districts of the North-Western Provinces.

Rain in Upper India was confined during the previous day to the hill districts of the Punjab and North-Western Provinces. Moderate rain had also fallen in the eastern districts of Central India. Sutna and Rewah each received one inch.

14th January.—The barometric changes of the preceding 24 hours were generally small in Northern and Central India, except in Quetta and in Sind and the North-West Punjab.

The fall in that area varied from ·05 inch to ·10 inch. The barometer had fallen irregularly in Central India and the Central Provinces—a condition which is frequently the only marked barometric indication of the occurrence of thunderstorms in India.

Temperature was increasing rapidly in Upper India and at the hill stations. A large increase in the amount of vapour pressure was shown at the Sind stations, and an even greater rise in Central India and the Central Provinces, produced mainly by the rain-fall in that area.

In other districts the amount of aqueous vapour were either steady or diminishing. The following shows the increase at stations in the areas where rain had fallen during the previous 24 hours:—

Province,	Representative station,	AQUEOUS VAPOUR PRESSURE,		Change in 24 hours.
		11th.	12th.	
SIND	Kurrachee	'312	'410	+ 098
	Jacobabad	'250	'370	+ '120
CENTRAL PROVINCES	Jubbulpore	'419	'538	+ '119
	Hoshangabad	'418	'602	+ '184
CENTRAL INDIA	Sutna	'421	'453	+ '032
	Nowgong	'335	'505	+ '170

Winds were somewhat irregular in the Gangetic plain but continued to show a preponderance of easterly winds—in part at least due to a tendency to feeble cyclonic circulation—over the area of disturbance in Central India. Winds were very abnormal in Sind and unrelated to those at Quetta, and apparently only explicable on the assumption of much irregular action and no defined centre, either cyclonic or anti-cyclonic. In the coast districts both of the Bay and western India the winds were normal in direction but lighter than usual, and hence indicated the absence of any indraught from the sea area in the lower atmospheric strata.

Snow had fallen at Quetta and rain in Sind, but elsewhere in Northern India weather was fine and dry with moderate cloud. Thunderstorms again visited the eastern districts of Central India, and larger amounts of rain were received in that area than on the previous day. The following gives the most noteworthy falls:—

Sohagpur	. 2'50 inches.
Sitlaha	. 1'93 "
Rewah	. 1'68 "
Nagode	. 1'48 "
Sutna	. 1'10 "

13th January.—The barometer was falling generally but the changes were very irregular, pointing to a disturbed state of the atmosphere over a large area but without any definite centre. The barometer fell rapidly in the Punjab and the Punjab Himalayas, Rajputana and the north-western districts of the North-Western Provinces. Pressure differed from the normal by very variable amounts, the deficiency being greatest at Murree (·15 inch) and Jeypore (·27 inch). The distribution was thus peculiar and pressure high in North-Eastern India and low in the Punjab, Central Rajputana and the eastern districts of Central India or in a long trough stretching from Lahore to Saugor.

The following data show the amount of the pressure changes and variations from the normal in different parts of the area :—

AREA.	STATION.	PRESSURE.	
		Change in past 24 hours.	Variation from normal.
PUNJAB HILLS	Quetta	+028	-092
	Murree	-137	-151
	Simla	-137	-114
	Chakrata	-092	-074
PUNJAB 'PLAINS	Mooltan	-145	-125
	Peshawar	-130	-125
	Lahore	-136	-133
SIND	Jacobabad	-093	-046
	Kurrachee	+034	-018
RAJPUTANA	Jeypore	-077	-144
	Deesa	-006	-066
NORTH-WESTERN PROVINCES.	Roorkee	-101	-104
	Agra	-092	-127
	Allahabad	-051	-057

The observations show that a considerable depression had formed over the Punjab, East Rajputana and the adjacent districts of the North-Western Provinces. This depression, superimposed upon the normal cold weather distribution of pressure, gave rise to a very complicated distribution, the chief features of which were shallow, low pressure areas in the South-East Punjab, Berar and Malabar, and high pressure areas in Assam, North Bengal and Bihar, Sind and Central India.

The whole of the available observations indicate that this depression in Upper India formed in that area on the afternoon and night of the 12th, and that it was probably due mainly to the ascensional movement and expansion accompanying cloud formation and rainfall. It was, in other words, a shallow, secondary depression due to a primary disturbance in Central India and the Central Provinces.

The following gives comparative data of the cloud amount and rainfall in North-Western and Central India for 10 A.M. of this day :—

AREA.	AVERAGE CLOUD AMOUNT AT 10 A.M. OF		Change.	RAINFALL.	
	12th.	13th.		Average fall in 24 hours preceding 6 P.M., 13th.	Largest amount in area.
Punjab hills	10'0	10'0	0	Inches. 0'68	Inches. 1'40
" plains	7'8	8'0	+0'2	0'30	2'06
North-Western Provinces hills	9'0	10'0	+1'0	0'94	1'67
" " plains	7'0	8'7	+1'7	0'45	1'23

Area.	AVERAGE CLOUD AMOUNT AT 10 A.M. OF		Change.	RAINFALL.	
	12th.	13th.		Average fall in 24 hours preceding 6 A.M., 13th.	Largest amount in area.
				Inches.	Inches.
Oudh	8.0	2.0	—6.0	0.21	0.55
Sind	9.3	0	—9.3	0.03	0.13
Rajputana	9.0	9.0	0	0.12	0.45
Central India	8.0	9.3	+1.3	0.66	1.92
Berar	3.5	0.5	—3.0	0.19	0.86
Central Provinces	4.7	6.0	+1.3	0.32	3.31

Rain had fallen over a large area including the Punjab, Rajputana, Central India, northern districts of the Central Provinces, the North-Western Provinces, Oudh and Bihar. It was light to moderate in amount, except in the Central Provinces, Central India and the hill districts, where falls of 1 to 2 inches were common.

Moderate snow showers fell at the hill stations, but the fall was nowhere large.

Skies were overcast over the hill districts, and in Rajputana, Central India and the greater part of the North-Western Provinces, and the amount of aqueous vapour had increased and was very considerably above the normal. The increase occurred chiefly over the area of rainfall and not in Bihar, where conditions were much the same as in the North-Western Provinces.

The following gives data for stations at which the increase was a twelfth of an inch or over:—

STATION.	AQUEOUS VAPOUR PRESSURE.		Change in past 24 hours.	Rainfall previous 24 hours.
	12th.	13th.		
	"	"		Incl.
Jeypore	337	432	+0.95	0.27
Agra	385	515	+1.30	Nil.
Allahabad	369	503	+1.34	0.67
Patna	409	490	+0.81	0.12

Hence the large changes in the amount of aqueous vapour occurred in the area of rainfall, and were the result partly of the direct action of the falling rain and partly of the evaporation of the fallen rain from the surface of the earth.

14th January.—The barometer was falling generally in India at this time. In Upper India this change was marked by the changes due to the disturbance. Pressure increased at Quetta and in Sind, Rajputana and the Punjab plains, but continued to fall at the Western Himalaya stations. The variations from the normal were small except in the North Punjab and at the hill stations, where there was a considerable deficiency, greatest at Murree (-21").

The following data show fully the character of the barometric changes in Northern India :—

STATION.	BAROMETER.	
	Change in past 24 hours.	Variation from normal.
HILLS—		
Murree	—'053	—'204
Simla	—'033	—'146
Chakrata	—'014	—'085
PLAINS—		
Peshawar	—'019	—'156
Lahore	+ '040	—'058
Agra	+ '083	—'047
Allahabad	—'003	—'054
Patna	—'061	—'029
Jeypore	+ '066	—'070
Deesa	+ '094	+ '028
Saugor	+ '004	—'079

Hence the distribution of pressure was as complex as on the 13th. There were shallow low pressure areas in the East Punjab and adjacent Himalayan area and in the eastern districts of Central India, in addition to the permanent low pressure area in the south of the Bay, Ceylon and the Arabian Sea (*i.e.* the equatorial belt of low pressure).

The winds were very abnormal and showed that there was much irregular disturbance. They were northerly in Lower Bengal and Orissa and easterly in the Gangetic plain, a strong proof that the easterly winds in the Gangetic plain during periods of unsettled conditions in the cold weather are not sea winds. Winds were very irregular in Central India and the Central Provinces.

North-westerly winds were setting in over Sind and the local Punjab.

Skies were overcast in the hills and more or less clouded in the East Punjab, the Gangetic plain, Central India, Orissa and Rajputana. They had cleared in Sind and a rapid reduction of the amount of aqueous vapour in the air had already taken place in that area.

Snow had fallen in large amounts in the hills, causing the usual large reduction of temperature (night and day), averaging 12° in amount at Simla and Murree.

15th January.—The barometer rose very rapidly at the Punjab hill stations and in the Punjab and East Rajputana, so that pressure was now somewhat above the average on the plains. It was still nearly a tenth below at the hill stations. A rapid fall had, however, occurred in Bengal and at Darjeeling, and a slight fall at Ranikhet.

The following data show the character of the changes :—

	STATION.	BAROMETER.	
		Change in past 24 hours.	Variation from normal.
(1) RISE IN UPPER INDIA	Peshawar	+ '252	+ '083
	Lahore	+ '123	+ '033
	Jeypore	+ '103	+ '015
	Jacobabad	+ '128	+ '096
	Murree	+ '170	— '034
	Simla	+ '050	— '096
(1) FALL IN NORTH-EASTERN INDIA	Darjeeling	— '118	— '125
	Sibsagar	— '145	— '172
	Dhubri	— '107	— '142
	Purneah	— '096	— '115

The only reasonable explanation appears to be that the disturbance in the Western Himalayas had been propagated rapidly eastwards. Winds had increased very rapidly at Darjeeling and were blowing strongly from west.

Temperature was above the average in Bengal, Bihar and the eastern districts of the North-Western Provinces. It was, on the other hand, very cold at the hill stations (15° below the normal at Murree and Simla) and a wave of cold and excessive dryness was advancing eastwards, the limit or front of which at 8 A.M., was about Jeypore and Agra. Northerly and westerly winds again prevailed in Upper India, and also in Bengal, where they were apparently due to the depression passing eastwards through it.

Snow fell on the afternoon and evening of the 14th and skies then began to clear at the hill stations. They were clear over nearly the whole of Northern India and there was no cloud in the Bengal area of depression (not even at Darjeeling).

The following table gives data illustrating the rapid fall of temperature in the area in Upper India in which the skies had cleared and north-westerly winds had set in :—

DISTRICT.	STATION.	VARIATION OF			Change in aqueous vapour pressure in past 24 hours.	Cloud.
		Maximum temperature from normal.	Minimum temperature from normal.	Mean from normal.		
RAJPUTANA .	Deesa	— 6'1	— 6'5	— 6'3	— '117	0
	Jeypore	— 4'6	— 10'2	— 7'4	— '208	1
NORTH-WESTERN PROVINCES .	Agra	— 3'0	— 2'2	— 2'6	— '168	0
PUNJAB	Peshawar	— 11'8	— 7'7	— 9'8	— '065	0
CENTRAL INDIA	Indore	— 4'1	— 7'7	— 5'9	— '028	0
	Murree	— 16'6	— 13'5	— 15'1	— '004	3
HILLS	Simla	— 17'2	— 11'6	— 14'4	— '030	5
	Darjeeling	+ 0'6	— 0'4	+ 0'1	— '135	0

The observations of the 16th show no further trace of the disturbance. Westerly winds prevailed over the whole of Northern India and the cool dry wave which had reached the latitude of Jeypore on the 14th had now extended to Bihar and Chota Nagpur. As very fine weather prevailed in India generally it is not necessary to discuss the observations.

The following gives a summary of the more important features of the disturbance :—

- 1st.*—It apparently consisted of two separate disturbances. The smaller one, judging from the barometric changes, formed in Central India and the Central Provinces on the 12th and remained almost unchanged in position until it disappeared on the 14th. The second part of the disturbance formed on the evening of the 12th in the East Punjab and covered that area and the adjacent districts of the North-Western Provinces and Rajputana on the 13th and 14th. The latter was very rapidly transferred eastwards along the Himalayas on the 15th and disappeared on the 16th.
- 2nd.*—The combined disturbance gave moderate and general rain over the greater part of Northern and Central India from the 13th to the 15th. The following gives a summary of the rainfall during the storm :—

District.	AVERAGE RAINFALL OF			Total of period.
	13th.	14th.	15th.	
Punjab	Inch. 0'30	Inch. 0'18	Inch. 0'01	Inch. 0'49
Sind	0'03	0	0	0'03
North-Western Provinces	0'45	0'31	0'03	0'79
Oudh	0'21	0'07	0'01	0'29
Rajputana	0'12	0	0	0'12
Central India	0'66	0'29	0	0'95
Central Provinces	0'32	0'14	0	0'46
Berar	0'19	0'01	0	0'20

- 3rd.*—The temperature conditions during the storm were very clearly marked.

During the advance of the storm, both day and night temperatures diminished largely at the hill stations. In the plains the day temperature was reduced below the normal and the night temperature raised above it. After the filling up of the storm and the clearing up of the sky a general reduction of temperature and of humidity occurred over the whole of Northern India.

- 4th.*—The air movement in the disturbed area showed much irregularity, and winds were throughout very light and exhibited a feeble tendency towards cyclonic circulation in the area of disturbance. The winds remained steadily at north on the Bengal coast and at east on the Bombay coast from the 12th to the 15th, thus showing that there was no indraught of sea or humid winds in the lower atmosphere during the period of heavy rainfall.

Disturbance of the 17th to the 23rd January 1887.—17th January.—Pressure was almost everywhere in slight excess and was generally rising. The changes however were small and fairly uniform; and hence the anti-cyclonic pressure distribution which was established on the breaking up of the previous storm, still continued. Pressure was highest in the mid-Indus Valley, where it was 30·2 inches, and lowest in the south of the Bay, where it was 29·98 inches, or ·22 inch lower than in Upper Sind. Temperature was everywhere below the average, the day temperature being exceptionally low in the Punjab. Temperature was increasing, except in the Punjab, where northerly winds accompanied a considerable decrease, which was greatest near the hills. Thus, the mean temperature of the previous 24 hours was 8·3° in defect at Rawalpindi and Sialkot, and 7·4° in defect at Ludhiana and Roorkee.

Light westerly winds or calms prevailed in the Gangetic valley and as far east as Central Bengal, whilst at the Bengal coast stations easterly winds obtained.

Skies were clear or partially clouded in Upper India and the Himalayan hill districts, and the changes of aqueous vapour small in amount and of no significance. The previous 24 hours were rainless, with the exception of one or two light showers at the hill station of Murree.

It will thus be seen that normal conditions obtained on the plains and that fine weather with clear or light clouded skies and light westerly or northerly winds prevailed over the whole of Northern and Central India. The following gives pressure data for the selected stations in Upper India for the 18th:—

DISTRICT.	STATION.	BAROMETER.	
		Change in past 24 hours.	Variation from normal.
		"	"
Hills Baluchistan	Quetta	—·084	—·176
" Punjab	Murree	—·054	—·112
	Simla	—·042	—·100
" North-Western Provinces	Chakrata	—·035	—·084
	Dera Ismail Khan	—·183	—·140
Plains Punjab	Peshawar	—·136	—·118
	Lahore	—·076	—·081
	Delhi	—·124	—·118

18th January.—The observations of the previous day show that the skies were beginning to cloud over in North-Western India. This evidence of the commencement of ascensional movement is confirmed by the observations of the 18th. The barometer had fallen

rapidly over the whole of Upper India during the previous 24 hours. The following table gives data, showing the amount and character of the fall:—

	AREA.	STATION.	BAROMETER.	
			Change in past 24 hours.	Variation from normal.
	Rajputana	{ Jeypore	—129	—136
		{ Deesa	—111	—151
	Sind	{ Jacobabad	—111	—054
		{ Kurrachee	—049	—081
		{ Agra	—109	—104
	North-Western Provinces	{ Lucknow	—059	—096
		{ Allahabad	—076	—102

The skies had continued to cloud over, and were now overcast over the whole of Upper and Central India, (*i.e.* the Punjab, the western half of the North-Western Provinces, North Sind and Rajputana). Over the remainder of India skies were clear. A rapid increase in the mean temperature of the day, averaging 7° , had occurred in the same area, chiefly due to largely increased night temperature. Winds were very light and were somewhat irregular. Light westerly winds continued in Bihar and Chota Nagpur and easterly winds on the Sind and Bombay coasts. There was hence up to this period no influx of sea winds. At the hill stations there was a slight decrease in the amount of aqueous vapour in the air, apparently only explicable on the supposition of an ascensional and (perhaps) expansive movement of the air.

The following table gives the average cloud amount and average humidity of the 18th and the previous two days at the hill stations in the Punjab, Sind, Rajputana and the North-Western Provinces:—

STATION OR DISTRICT.		CLOUD AMOUNT AT 10 A.M. OF			AQUEOUS VAPOUR.		
		16th.	17th.	18th.	16th.	17th.	18th.
Hills	Quetta	9'0	10'0	10'0	'160	'207	'232
	Murree	10'0	0	10'0	'131	'166	'153
	Simla	10'0	8'0	10'0	'172	'162	'169
	Chakrata	10'0	4'0	10'0	'209	'154	'119
Plains	Punjab	8'9	4'8	10'0	'259	'267	'285
	Sind	3'0	3'3	4'0	'204	'232	'307
	Rajputana	0	4'5	6'5	'269	'255	'227
	North-Western Provinces	1'3	4'1	4'4	'301	'338	'357

The weather was as yet practically rainless, and even up to 6 P.M. of the day no rain fell beyond some light local showers, chiefly at the hill stations, *e.g.*, Quetta, Kilba and Naini Tal. Hence the fall of the barometer was simultaneous with the clouding over of the skies, and both preceded the occurrence of rainfall by several hours.

19th January.—The barometer fell over the whole of India during the previous day. The fall was large in Upper and Central India and was somewhat larger at the plains than the hill stations, but when density is taken into account it is evident that a larger ascensional rise took place at the level of the hills than the plains.

The greatest fall had occurred in Central India and the Central Provinces, and a slight depression had formed in that area. The area was defined by the isobar of 29.90", and pressure was from a fifth to a quarter of an inch below the normal over this area. The following table gives barometric data of the depression:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in previous 24 hours.	Variation from normal	Direction.	Force.	
Nowgong	29.895	—142	—243	Calm	1	9
Jeypore	915	—110	—240	ES-E	6	10
Ajmere	923	—103	—219	N-E	8	9
Khandwa	898	—071	—183	W	4	0
Hoshangabad	889	—125	—216	S.W	0	0
Jubbulpore	966	—084	—156	SS-E	1	1
Sutna	912	—134	—212	ES-E	5	3
Lahore	935	—134	—202	N-W	4	10
Mooltan	970	—071	—178	Calm	0	7
Deesa	891	—036	—189	N	6	3
Surat	934	—028	—136	N-W	?	0
Poona	972	—028	—101	WN-W	6	1
Sholapur	926	—054	—132	SS-E	8	0

The first group of stations define the central area of depression. The data of the stations in the second group are given to show that the depression was very extensive but shallow. Thus, the difference between the depression below the normal at Lahore and the centre of the depression, a distance of over 500 miles, was less than a tenth of an inch, and probably not more than a twelfth of an inch. Winds were everywhere light, and in the majority of cases were much below normal strength, and were irregular in direction except in the area of depression, where there was generally a tendency to cyclonic circulation. Skies had cleared partially in Sind, and cloud had extended southwards into Central India and eastwards to the central districts of Bihar. There was as yet no cloud in the Central Provinces, and all stations in that area and Bengal reported fine clear weather.

The following gives the average cloud amount at 10 A.M. in different districts:—

Punjab—					
Hills	10.0	Sind	8.3		
Plain	6.8	Rajputana	9.5		
North-Western Provinces—		Central India	4.0		
Hills	10.0	Central Provinces	0.4		
Plains	9.0	Bihar	3.8		
		Bengal	0.3		

Winds were unchanged in Bengal, but had shifted to east in Bihar. A slight increase of aqueous vapour had occurred in Upper India and the hill districts. Temperature was falling rapidly at the hill stations with the occurrence of snow, and also in the Punjab. Elsewhere it was generally rising.

Rain had fallen over the districts to the north of the depression area, *viz.* the Punjab (East), Rajputana (north and east districts), the North-Western Provinces (except Oudh and south-east districts) and North Bihar. Moderately heavy snow had been received in the hill districts. The following gives an analysis of the rainfall of the previous 24 hours:—

DISTRICT.	Average rainfall.	Heaviest rainfall.
	Inch.	Inch.
Punjab	0·04	0·40
North-Western Provinces	0·16	0·76
Oudh	0·08	0·35
Rajputana	0·08	1·26
Bihar and Chota Nagpur	0·06	0·30
Bengal and Orissa	Nil	0·10

20th January.—The barometer had fallen over the whole of India except Sind and West Rajputana. There were two areas in which the fall exceeded a tenth of an inch, *viz.* the North-West Punjab and hill stations (at which it was greatest), and at Allahabad, Lucknow and Raipur. There were hence two areas of very low pressure at this time (defined by the isobars of 29·85"). The first included the North Punjab.

The following gives barometric data of this area:—

STATION.	BAROMETER.			WIND.		Cloud at 10 A.M.
	Actual reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.	
Leh?	?	—0·078	?	N-E	1	10
Quetta	?	+0·012	—152	N-W	5	3
Murree	?	—108	—302	Calm	6	10
Simla	?	—152	—314	S-E	?	10
Lahore	29·872	—063	—257	Calm	2	0
Sialkot	·834	—088	—283	E	?	9
Rawalpindi	·886	—116	—293	NN-E	2	6
Peshawar	·842	—137	—310	WN-W	2	0
Dera Ismail Khan	·846	—119	—308	Calm	1	0
Mooltan	·860	—140	—281	Calm	0	0

Skies were clear over the greater part of the Punjab, but were overcast in the hill districts to the east. The air was slightly drier and the amount of aqueous vapour almost universally less than on the previous day. Pressure was slightly more than three-tenths

of an inch below the normal in this area, and the deficiency was on the whole actually greater at the hill stations in the Punjab and North-Western Provinces than at the level of the plains, and hence it is almost certain that the central depression was over the Himalayan area itself.

The second area of local depression stretched from Allahabad to Raipur and was evidently the continuation of the low-pressure area in the Central Provinces on the 19th.

The following gives barometric data of this area :—

STATION,	BAROMETER.			WIND.		Cloud at 10 A.M.
	Actual reduced to sea-level and constant gravity.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity during past 24 hours.	
Benares	29.850	—150	—281	S-E	7	9
Allahabad	819	—158	—316	Calm	8	9
Sutna	845	—067	—304	W	8	5
Seoni	867	—036	—242	Calm	5	3
Raipur	847	—065	—258	WS-W	8	2
Sambalpur	881	—076	?	S-W	1	3

Skies were overcast in this area, and also in Bihar, and the air was generally damper. Winds were very light and irregular in the Punjab. North-westerly winds obtained in the western districts of the North-Western Provinces and Rajputana. In the area of depression a feeble cyclonic circulation of an irregular kind appeared to obtain and it influenced the winds to some extent in Bengal, as they had generally shifted round to some easterly direction. Northerly winds still prevailed in East Bengal.

Moderate snow fell in the Himalaya hill districts, and light to moderate rain to the north-west, north and north-east of the primary depression, in Rajputana, the North-Western Provinces and Bihar, and one or two local showers in Central India.

The following gives data of the rainfall of the previous 24 hours. It shows that the rainfall was heaviest to the north-east of the area of depression, *vis.* Bihar and the North-Western Provinces, and that no rain fell to the south of the central area :—

DISTRICT.	Total number of stations.	Number at which rain fell.	Average rainfall previous 24 hours.	Heaviest rainfall recorded.
			Inches.	Inches.
Punjab	30	12	0.15	0.60
Rajputana	40	11	0.04	0.27
Central India	18	6	0.07	0.40
North-Western Provinces	38	26	0.42	1.65
Oudh	12	8	0.15	0.45
Bihar and Chota Nagpur	27	24	1.07	2.12
Bengal	138	56	0.34	2.04
Assam	13	6	0.10	0.43
Central Provinces	26	4	0.01	0.15

• *21st January.*—The barometer had risen rapidly in Upper India and the depression in that area had filled up. Light to moderate snow had fallen in the hill districts, but no rain on the Punjab plains. Skies were cloudy in the hills, but, as usual during snowfall, temperature in the hills was very low, *e.g.*, 14° below the normal at Simla. The barometer had fallen locally in Bengal and Orissa, and in the north of the Bay, and the depression, which was between Allahabad and Raipur on the 20th, now covered West Bengal and the north-west of the Bay between Saugor Island and False Point. Winds were more or less irregular over nearly the whole of Northern India. Even in the area of depression they were by no means cyclonic in direction. Temperature (more especially the night temperature) was much above the normal in Bengal, and skies were overcast in Assam and Bengal, but were clear in Burma. They were rapidly clearing in Upper and Central India. The rainfall of the previous day occurred almost exclusively to the north and north-east of the area of depression, *vis.* Bengal (chiefly east and south districts), Assam, Chota Nagpur, and Burma (Upper). None fell in the Punjab, Rajputana, the North-Western Provinces, Berar and Central India.

The following statement gives an analysis of the rainfall :—

AREA.	Total number of stations.	Number at which rain fell.	Average rainfall previous 24 hours.	Heaviest rainfall recorded.
			Inches.	Inches.
Bihar and Chota Nagpur	27	12	0'11	0'83
Orissa	14	4	0'06	0'45
Bengal	42	37	0'36	1'28
Assam	13	13	0'23	0'50
Burma	28	7	0'09	1'47

22nd January.—The barometric changes were small and unimportant in North-West India. The barometer fell in Burma and Bengal to a slight extent, the fall being greatest on the Arakan coast. These changes were due to the transfer of the area of depression from the north-west of the Bay to the north-east. Pressure was below the average by nearly equal amounts over the whole of Northern India, varying from '21" at Chittagong and Dacca to '11" at Lahore, and hence the relative depression off the Arakan coast was very small in amount. Skies were overcast in Bengal, Assam and North Burma, and were now generally free from cloud in the Gangetic plain.

Light to moderate westerly winds had set in in the Punjab, the North-Western Provinces and Bihar. They had produced a large decrease in the amount of vapour present in the air and gave low temperatures both by day and night over the area of their prevalence. The air was, on the other hand, much damper in Upper Burma, Arakan, etc., chiefly due to the setting in of southerly winds. Temperature (more especially the night temperature) was, consequently, much above the normal in South Bengal and Burma.

The rainfall of the preceding 24 hours was confined to Bengal, Assam and Burma. The following gives data :—

DISTRICT.	Average rainfall.	Heaviest rainfall.
	Inches.	Inches.
Bengal	0'15	1'57
Assam	0'25	0'74
Burma	0'19	1'11

23rd January.—Pressure increased rapidly over the whole of Northern India. The rise was greatest in East Bengal, Arakan and Upper Burma, where it averaged nearly a sixth of an inch. The depression* passing into East Bengal and Arakan on the 22nd had hence either filled up or passed eastwards beyond the limits of Upper Burma.

Temperature was rising rapidly at the Punjab hill stations and slowly in the Punjab. It had fallen rapidly in Bengal, and the mean temperature of the preceding 24 hours was from 4° to 7° below the normal. Skies had cleared and were now free from cloud over the whole of Northern India, including Assam and Upper Burma. Strong westerly winds were blowing down the Gangetic plain and had extended into Central Bengal. They had caused a very great reduction in the amount of vapour in the air, which was now in West Bengal little more than half of the amount present on the morning of the 22nd.

During the remainder of the month two feeble depressions crossed the north-west frontier and advanced across the South Punjab towards the Himalayas, and were apparently broken up by these hills. The first appeared on the 24th in Upper Sind, gave light showers on the 25th in the Punjab and filled up on the afternoon of that day. It was of little importance. The second of these depressions appeared on the 27th in the South-West Punjab and North Rajputana, and intensified on the 28th. It commenced to fill up on the 29th, and at the same time moved slowly to the east and disappeared in the Himalayas of the North-Western Provinces. The following data show the character of the barometric oscillation accompanying the storm:—

STATION.	Fall from 10 A.M. of 27th January to 10 A.M. of 29th.	Rise from 10 A.M. of 29th to 10 A.M. of 31st.	STATION.	Fall from 10 A.M. of 27th January to 10 A.M. of 29th.	Rise from 10 A.M. of 29th to 10 A.M. of 31st.
Quetta	+ '007	+ '102	Jacobabad	— '073	+ '142
Murree	— '152	+ '096	Mooltan	— '119	+ '151
Simla	— '090	+ '014	Sirsa	— '206	+ '174
Mussooree	— '080	+ '004	Kurrachee	— '048	+ '089
Ranikhet	— '098	+ '014	Deesa	— '110	+ '092
Peshawar	— '117	+ '106	Jeypore	— '189	+ '172
Rawalpindi	— '122	+ '079	Agra	— '216	+ '156
Dera Ismail Khan	— '100	+ '108	Roorkee	— '175	+ '094
Lahore	— '150	+ '129			

Moderate rain fell during the storm in the North Punjab, Bengal, Assam, and a few showers in Upper Burma, and some heavy snowfalls occurred in the North-West Himalayas and on the Afghan hills, and very heavy snowfall in the Eastern Himalayas.

1887-88.

Chief abnormal features of the Meteorology of India in 1887.—The cold weather in 1887 was, as has been shown, unusually free from cold weather storms. March and April were much warmer than usual in the Punjab, Rajputana and the Central Provinces, and more free from disturbance than usual. May was an excessively hot and dry month in Upper and Central India, and the conditions in the last fortnight were very favourable for a strong and early monsoon. The Bengal current set in earlier than usual at the end of May, and the Bombay current at the normal date on the west coast. Both currents gave fairly steady rain during the months of June, July and August, and

retreated from Upper and Central India about the 20th September. There was a slight deficiency in the rainfall over Arakan, Bengal, Assam and Orissa, and an excess over nearly the whole of Upper and Central India and the Central Provinces. In Burma and the Peninsula the rains were normal. The north-east monsoon rains set in normally on the Madras coast and gave heavier and more regularly distributed rain than usual (owing to the absence of cyclonic storms). The weather also continued liable to slight disturbances in the Arabian Sea off the west coast, and the west coast districts hence received unusually abundant rain. The rains ceased in Southern India about the 30th of December.

The following table gives a comparative statement of the variations of the rainfall from the normal for the south-west monsoon period and the retreating south-west monsoon period in 1887 :—

AREA.	ORDINARY SOUTH-WEST MONSOON RAINFALL, JUNE TO SEPTEMBER 1887.		RETREATING SOUTH-WEST MONSOON RAINFALL, OCTOBER TO DECEMBER 1887.	
	Variation from normal.	Variation expressed as percentage.	Variation from normal.	Variation expressed as percentage.
	Inches.		Inches.	
Western Himalayas	—0'40	— 1	—1'62	—58
Punjab Plains	+2'63	+16	—0'89	—76
North-Western Provinces and Oudh	+4'27	+13	—0'06	— 3
Rajputana	+2'54	+11	—0'26	—41
India	+7'33	+18	+1'58	+66
Bihar	—5'13	—14	+0'53	+15
Western Bengal and Chota Nagpur	—4'06	—12	—2'17	—54
Lower Bengal	—6'06	—12	—1'06	—20
Eastern Himalayas	—6'95	— 7	—1'31	—22
Assam and Eastern Bengal	—6'68	— 8	—3'62	—52
Orissa and Northern Circars	—2'25	— 6	—1'75	—21
Central Provinces, South	+12'22	+26	+1'14	+38
Berar and Khandesh	+9'21	+28	+4'24	+101
Guzerat	—0'62	— 2	+0'09	+ 8
Sind and Cutch	—4'14	—52	—0'31	—89
North Deccan	+0'59	+ 3	+2'41	+38
Konkan and Ghats	+10'10	+ 7	+3'32	+55
Malabar and Ghats	—4'62	— 5	+6'94	+56
Hyderabad	+1'09	+ 4	—1'75	—37
Ceded Districts and Mysore	+1'77	+11	+2'72	+32
Carnatic	—0'23	— 2	+10'46	+56
Nilgiris	—2'24	—15	+5'80	+25
Ceylon	—4'08	—21	+8'61	+28
Arakan	—7'82	— 6	—4'51	—38
Pegu	—0'92	— 2	—5'92	—60
Tenasserim	—2'14	— 2	—4'54	—35
Bay Islands	+11'03	+19	+3'13	+10

The chief feature of the distribution of pressure at the end of the year was an excess in Northern India, greatest to the south of the Jumna. Pressure was slightly in defect relative to the general state in the Peninsula. The peculiar conditions in the Arabian Sea were to some extent indicated by persistent deficient pressure at the Konkan coast stations. The cessation of general rainfall in any large area in India is frequently accompanied by a reversal of the existing conditions. Hence no change occurred in Northern India at the end of the rains, due to the retreating south-west monsoon, whilst a local excess was established in Southern India. The following were the chief features of the pressure distribution at the commencement of the cold weather period of 1888 :—

- (1) A general excess of pressure in India.
- (2) Local excess in Northern India and also in Southern India.
- (3) An intermediate belt of deficient pressure extending from Sind and Kathiawar through Central India to Central Burma.
- (4) Slightly deficient pressure in the Arabian Sea off the coasts of Kathiawar and the Konkan.

The following data show the relation between the pressure variations at the hill stations and neighbouring plain stations during the period September 1887 to March 1888 :—

MONTHS.	VERTICAL PRESSURE ANOMALY.					
	Leh HILL Lahore.	Quetta HILL Jacobabad.	Murree HILL Peshawar.	Simla HILL Ludhiana.	Ranikhet HILL Lucknow.	Darjeeling HILL Dibrui.
September 1887	—'017	+ '023	—'017	—'019	—'022	+ '010
October "	—'005	0	+ '006	—'014	—'028	+ '002
November "	+ '018	+ '019	+ '015	+ '017	—'018	—'006
December "	—'009	+ '014	—'007	—'001	—'007	+ '004
January 1888	—'052	—'023	—'034	—'051	—'052	—'017
February "	—'004	—'019	—'007	—'013	—'016	+ '008
Mean of period	—'011	+ '005	—'011	—'005	—'022	+ '005

November and December 1887 were dry months in Upper India. The weather in January and February 1888 was disturbed by a large number of small and shallow depressions, the majority of which were actually or practically rainless. There were five depressions and disturbances in January, of which three were of some importance.

Five also passed into and across Northern India in February. All were shallow, and gave little snow except in the Punjab. Two depressions also appeared in March, similar in character to those of the two preceding months. Hence, although there were an unusually large number of disturbances in the cold weather of 1887-88, they were almost without exception small and almost rainless.

The following table gives a statement of the variation of rainfall from the normal in Northern India during the cold weather period :—

DISTRICT.	COLD WEATHER RAINFALL PERIOD, DECEMBER 1887 TO 31ST MARCH 1888.	
	Variation from normal.	Variation expressed as percentage.
	Inches.	
Western Himalayas	-2'26	-22
Punjab plains	-0'99	-26
North-Western Provinces and Oudh	-0'31	-14
Rajputana	+0'95	+125
Central India States	+0'45	+27
Bihar	-0'64	-39
Western Bengal and Chota Nagpur	+0'02	+1
Lower Bengal	+0'02	+1
Eastern Himalayas	+0'83	+20
Assam and Eastern Bengal	+1'58	+26
Orissa and Northern Circars	-0'45	-20
Central Provinces, South	+0'62	+34
Berar and Khandesh	+1'43	+98
Guzerat	+0'84	+300
Sind and Cutch	+1'92	+240
North Deccan	+0'59	+69

The rainfall of the period was hence in slight to moderate defect in Northern India. The following is a summary of the information relating to the amount of the snowfall in the mountain districts adjoining Northern India in 1887-88.

Over the greater part of the Afghan highlands the precipitation was, on the whole, less than usual, except on the Spinghar and Safed Koh mountains, where heavy snow fell in January and February. Although the snow melted rapidly in March and April, there was still a large accumulation on the Safed Koh at the end of April.

In the Western Himalayas the snowfall of the season was unusually small in amount previous to the last week of March. Heavy snow fell in some parts of the Kashmir Himalayas in April, but it was very local.

The snowfall in the Eastern Himalayas was also stated to be somewhat smaller than in the previous year, but was probably normal in amount and distribution.

Storms of the cold weather period 1887-88.—The first was an abnormal and diffused disturbance, which gave unusual and untimely rain in North Bombay and Kathiawar and Berar. The second and third were disturbances of the ordinary cold weather type.

The first important cold-weather disturbance of the month of January 1888 was very unusual in character. So far as is indicated by the land observations it was apparently due to the formation of a depression off the Bombay coast at the end of December. It remained almost unchanged in character and position from the 1st to the 5th of January. During this period showers were received daily in the Bombay coast

districts from Karwar to Bombay and in the Central Provinces and Berar. Pressure was considerably above the normal over the whole of India by amounts ranging from '03 inch on the Bombay coast to '02 inch in the North Punjab and Upper Assam.

The following gives a statement of the rainfall day by day in these two areas :—

DISTRICT.	Average rainfall of 24 hours preceding 10 A.M. of					
	1st.	and.	3rd.	4th.	5th	TOTAL.
	Inch.	Inch.	Inch.	Inch.	Inch.	Inches.
Bombay	0	0'08	0'13	0'64	0'06	0 91
Berar	0	0'01	0'07	0 87	0'57	1'52
Central Provinces	0	0'09	0 12	0'24	0'58	1'03

The disturbance was hence in many respects very peculiar. Pressure gave way slightly on the 31st and 1st, and after that increased slowly and steadily until the 6th over the whole of India. The disturbance, to whatever it may have been due, appears to have passed quickly eastwards on the 5th, as rain ceased on that day in Western India, and light showers fell in Bengal, as well as in the Central Provinces. Fine clear weather set in, with a rising barometer on the 6th and continued for some days—in fact, until the 10th.

A small depression and disturbance passed over Bushire on the 8th and 9th January. The following gives the chief observations at that station showing the character of the disturbance :—

STATION.	Date.	PRESSURE.			WIND.		Rainfall in past 24 hours.	WEATHER.
		100 M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from Normal.	Direction.	Mean velocity previous 24 hours.		
		"	"	"		Miles.	Inch.	
Bushire	6th	30'167	—'040	+ '042	S-E	6	<i>Nil</i>	Passing clouds.
	7th	'130	—'037	—'003	S-E	8	0'17	do.
	8th	'080	—'050	—'062	S-E	6	0'18	do.
	9th	'003	—'077	—'169	N-E	7	0'51	do.
	10th	'207	+ '204	+ 014	N	18	0'28	do.

This disturbance apparently passed over Quetta and Peshin on the evening of the 10th, and on the morning of the 11th it lay as a very shallow depression over Sind, the centre of which was midway between Jacobabad and Hyderabad. Moderately heavy snow had fallen during the previous day on the Afghan and Baluchistan highlands, at Quetta, Peshin, and on the Zawa Hills, the Samana Range and the high mountain ranges in North Afghanistan. The depression at the centre was less than a tenth of an inch. It moved eastwards into South-West Rajputana on the 12th, and filled up during the succeeding 24 hours. Light showers were received in the North Punjab. It was hence of no importance in India. If it was the continuation of the disturbance which passed across

South Persia, it must have travelled at an average rate of between 300 and 400 miles per diem from the 8th to the 12th.

Pressure increased generally after the disappearance of the previous storm. Some light thundershowers of no importance were received on the 16th and 17th, after which weather was fine and settled until the 20th, on which day a rapid fall of the barometer in Sind and at Quetta indicated the approach of a disturbance eastwards across Baluchistan and the north of the Arabian Sea. The following gives an account of this disturbance.

Depression of the 20th to the 25th January 1888.—On the 18th and 19th anti-cyclonic conditions obtained over North-West India, pressure exceeding 30·20" over the greater part of that area. The barometer commenced to fall on the evening of the 18th. The fall was rapid in Baluchistan and the North-West frontier on the 19th, and on the morning of the 20th a moderate depression overlay Baluchistan and the adjacent portion of the Arabian Sea. Skies were clear over the whole of India almost without exception at 10 A.M. of the 19th. The cloud amount at Quetta was 7 with light winds and a rising barometer at that hour. The following observations at 10 A.M. of the 20th show the change which had occurred during the previous 24 hours:—

STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from the normal.	Direction 10 A. M.	Mean velocity previous 24 hours.	
					Miles.	
Quetta	?	—·148	—·043	Calm	1	10
Mooltan	30·019	—·132	—·087	Calm	1	10
Jacobabad	29·969	—·186	—·093	S-E	1	5
Hyderabad	29·937	—·114	—·036	S-W	5	8
Kurrachee	30·034	—·093	—·024	W	6	5

The barometer had fallen except in Burma, Bengal and South India, but the changes were everywhere small except at Quetta and on the North-West frontier. Winds were lighter than usual over the area of depression, and except in Sind and Baluchistan showed no indications of cyclonic circulation. Westerly winds prevailed in the Gangetic plain, northerly winds in Bengal, and north-easterly in the Central Provinces—the normal anti-cyclonic cold weather winds of Northern-India. Temperature was very considerably below the normal in the whole of Northern and Central India, but was above it in Sind and Baluchistan. Skies were already overcast over the greater part of the Punjab and at Quetta, and were partially clouded in Sind and Rajputana. No rain had fallen during the previous day.

21st January.—The barometer had risen rapidly during the previous 24 hours in the Punjab and pressure exceeded 30·25" at Peshawar. It had also risen in all other districts except South-West Rajputana and Guzerat. A shallow area of depression, which was deepest in the area between Deesa and Indore, now extended from the Sind frontier to Guzerat, but the winds were very irregular and showed that there was no general well-

marked cyclonic circulation. The following gives observations at stations in Sind, Guzerat and Central India :—

DISTRICT.	STATION.	PRESSURE.			WIND.		Cloud at 10 A.M.
		10 A.M., reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from the normal.	Direction 10 A.M.	Mean velocity previous 24 hours.	
		Miles.	Miles.	Miles.		Miles.	
SIND	Kurrachee	29'961	—'073	—'091	ES-E	12	9
	Jacobabad	'980	+ '011	—'077	Calm	2	3
	Hyderabad	'933	—'004	—'090	NN-E	6	4
RAJPUTANA	Ajmere	30'051	—'030	—'034	S-E	2	3
	Bickaneer	29'962	—'029	?	SS-W	5	6
CENTRAL INDIA . . .	Indore	'934	—'099	—'093	S-E	2	0
	Neemuch	'976	—'071	—'086	ES-E	?	4
	Deesa	'987	—'053	—'045	EN-E	6	10
GUZERAT	Rajkot	'998	—'037	—'048	E (?)	4	2
	Surat	30'056	—'008	+ '029	WS-W	?	0

These observations show that the depression was deepest in Lower Sind at Hyderabad. Skies were less clouded in the Punjab, but were partially clouded over the whole of North-West and Central India, *i.e.* to the north-west of a line joining Rajkot and Benares. Light snow had fallen on the Afghan highlands and a few very light showers in the Punjab.

The disturbance was hence up to this hour of little importance and had given little rain. A remarkable change, however, occurred during the next 24 hours.

22nd January.—The observations show that there were on this day two areas of disturbance. The first was in the North Punjab, in which area a rapid decrease of pressure had followed a large rise on the 20th. The fall during the 24 hours preceding 10 A.M. of the 22nd was '2' at Rawalpindi and '16' at Murree.

The second area of disturbance is defined by the following stations: Agra, Sirsa, Ajmere, Indore and Saugor. In that area the observed fall was greatest at Jeypore, where it was '20'.

That depression was evidently the continuation of the disturbance which entered Sind from Baluchistan on the previous day and hence must be regarded as the primary disturbance, whilst the depression which had formed in the North Punjab was a secondary or subsidiary disturbance.

The following gives 10 A.M. data of the 22nd for stations in those two areas illustrating the character of the disturbance :—

DISTRICT.	STATIONS.	PRESSURE.			WIND.		Cloud, at 10 A.M.
		10 A.M., reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from the normal.	Direction 10 A.M.	Mean velocity previous 24 hours.	
		"	"	"		Miles.	
North Punjab (area of secondary depression).	Murree	?	—'164	—'129	S-E	16	10
	Peshawar	30'045	—'177	—'064	ES-E	1	6
	Rawalpindi	29'975	—'203	—'148	S-E	4	10

DISTRICT.	STATION.	PRESSURE.			WIND.		Cloud, at 10 A.M.
		10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from the normal.	Direction 10 A.M.	Mean velocity previous 24 hours.	
Rajputana and Guze- rat (area of primary disturbance).	Jeypore	29.380	—198	—209	S-E	Miles. 9	5
	Ajmere	.883	—163	—188	S	5	8
	Bickaneer	.877	—085	?	SS-W(?)	16	?
	Deesa	.887	—100	—137	WS-W	7	10

Winds were generally above their normal strength, but show much irregularity of direction, due chiefly to the interference of two depression systems of nearly equal intensity. Northerly land winds continued in Bengal, whilst easterly winds generally obtained in the Gangetic plain. Skies were overcast in the Punjab, the North-Western Provinces, Rajputana and Central India and partially clouded in the Central Provinces and Bihar. They were now free from cloud in Sind and at Quetta. Moderately heavy snow had fallen during the previous day on the Punjab Himalayas and in Baluchistan, and rain in the Punjab, the North-Western Provinces and Central India.

23rd January.—The barometer during the previous 24 hours rose rapidly in North-West India, briskly in the Peninsula and slightly in North-East India. It fell slightly in Baghelkhand, Chota Nagpur and the north-eastern districts of the Central Provinces. The disturbance in the latter area was the continuation of the depression in South-west Rajputana on the previous day. The Punjab depression had disappeared, having probably filled up, as there is no indication in the observations of a storm having passed across or along the Himalayas. Winds were, as on the 22nd, very irregular, but were from north-north-west in Lower Bengal and from directions between east and north on the West Coast, so that there were no sea winds blowing across either the Bengal or Bomlay coast. Skies had cleared in the West Punjab and Rajputana and were clearing in Central India and the Central Provinces, but were overcast in the North-Western Provinces, Bihar and Bengal.

Rain fell in the areas to the north and east of the two depressions of the previous day.

24th January.—The barometer continued to rise over the greater part of India. It fell in Bengal, Burma and Assam, the amounts being large in Bengal, more especially at Darjeeling (1.12"), Purnea (1.0"), Saugor Island and Burdwan (1.09"). The disturbance passed across Bengal and the head of the Bay during the day. As on the 23rd, it was not sufficiently marked to give rise to a well-defined depression area and cyclonic circulation. Westerly cool winds prevailed in the Gangetic plain, and skies were clearing in the Punjab, Rajputana and the North-Western Provinces. Showers were received in Bihar and Bengal during the previous 24 hours. The centre of the depression area was approaching the North Orissa hills at 10 A.M.

Pressure increased rather rapidly during the next 24 hours, and the 10 A.M. observations of the 25th give no indications of the existence of the disturbance. A slight fall in Burma may have been due to its continued eastward advance.

The disturbance was hence a double one, consisting of a shallow and feeble primary depression and of a stationary, shallow and comparatively feeble secondary

depression in the Punjab. The chief feature of the primary disturbance was that it advanced along a more southerly track than usual. It entered Sind on the 20th and probably passed into Central Burma on the 25th. The disturbance was feeble and the precipitation due to it was small in amount. The following gives a statement of the rainfall due to the storm:—

AREA.	RAINFALL OF 24 HOURS PRECEDING 6 P.M. OF					Total.
	21st.	22nd.	23rd.	24th.	25th.	
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
Punjab	0'01	0'45	0'16	0'01	0'24	0'87
Rajputana	0	0'03	0'01	0	0'17	0'21
Central India	0'03	0'16	0'01	0	0'03	0'23
North-Western Provinces and Oudh	0	0'08	0'35	0'03	0'04	0'50
Bihar and Chota Nagpur	0	0'03	0'44	0'06	0	0'53
Bengal	0	0	0'04	0'01	0'01	0'06
Assam	0	0	0	0'09	0'03	0'12

Storm of the 24th to the 29th January 1888.—This depression entered Upper India from Baluchistan, and was probably the continuation of a depression which advanced across Persia to the north of Bushire, on the 20th and 21st.

The following gives the daily barometric changes at Bushire, Quetta and Jacobabad from the 21st to 25th:—

DATE.	BAROMETRIC CHANGE AT		
	Bushire.	Quetta.	Jacobabad.
21st	—'004	—'010	+ '011
22nd	—'121	—'031	—'045
23rd	—'053	+ '079	+ '168
24th	+ '128	—'082	+ '074
25th	+ '096	—'002	—'117

The first indications of its approach to India were shown by the observations of Quetta and the Sind stations on the morning of the 24th. The following gives these observations:—

STATION.	PRESSURE.			WIND.		Cloud, 10 A.M.
	10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Mean velo- city, previ- ous 24 hours.	
Quetta	...	—'082	—'052	SS-W	5	10
Jacobabad	30'077	—'026	+ '027	NN-W	4	10
Kurrachee	30'059	—'017	+ '022	EN-E	11	5
Hyderabad	30'132	+ '003	+ '009	EN-E	9	10

Pressure had increased during the previous 24 hours in the Punjab, and was upwards of a tenth of an inch above the normal. Light westerly winds prevailed in the Gangetic plain, northerly winds in South Bengal and easterly winds in the Central Provinces and Central India, and the lower air circulation in Northern and Central India was hence normal in character. Skies were more or less clouded in Northern India, but were generally clear in Central India, the Deccan and Bombay.

25th January.—The barometer fell rapidly over the whole of North-Western and Central India, and the depression which was approaching the North-West frontier on the 24th had now advanced into South-West Rajputana. The following observations define its position approximately:—

STATION.	PRESSURE.			WIND.		Cloud, 10 A.M.
	10 A.M. reduced to sea- level and gravity 45° Lat 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Mean velocity, previous 24 hours.	
	"	"	"		Miles.	
Indore	29'987	—'064	—'040	S-E	2	1
Neemuch	30'024	—'098	—'038	SS-E	7	9
Jacobabad	30'060	—'117	+ '012	E	2	10
Hyderabad	30'067	—'065	—'056	N-W	5	10
Deesa	29'987	—'092	—'036	S-E	8	10
Surat	30'039	—'075	+ '012	W	7	0

The air movement was light and irregular over the whole area and plainly indicated that there was no well-marked cyclonic circulation in the lower atmospheric strata.

Winds were unchanged in direction in the Gangetic plain and Bengal. Skies were overcast in Sind, the Punjab, Rajputana and the western districts of the North-Western Provinces, and at all the hill stations. Rain had fallen in Sind and the Punjab. The barometer was falling rapidly in the North Punjab and at Murree, and a rapid increase had occurred in the wind at Murree, the first indications of the formation of a subsidiary depression.

26th January.—The observations of this day show that the primary disturbance had advanced in an east south-east direction into the central districts of the Central Provinces, and that a deepish secondary depression, the first indications of the formation of which had been shown by the observations of the 25th, covered the North Punjab. The following observations indicate the character and position of these two depressions:—

	STATION.	PRESSURE.			WIND.		Cloud, 10 A.M.
		10 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Mean velocity, previous 24 hours.	
		"	"	"		Miles.	
Primary depression .	Pachmarhi	?	—'097	—'104	W	4	2
	Nagpur	29'880	—'153	—'157	NW	4	1
	Seoni	'864	—'166	—'167	W	2	5
	Saugor	'946	—'097	—'110	E	6	6
	Jubbulpore	'949	—'116	—'132	Calm	1	0
Secondary depression .	Murree	?	—'082	—'203	Calm	5	10
	Peshawar	29'923	—'114	—'149	Calm	1	2
	Rawalpindi	'894	—'086	—'229	WNW	2	10
	Sialkot	'934	—'091	—'119	N	1	10

Winds in the Gangetic valley were mainly determined by the depression passing through the Central Provinces. In Bengal northerly winds continued, and hence were not as yet influenced by the advancing depression.

Winds were very light and irregular in the Punjab and at Murree, and the circulation in the secondary depression in that area was very feeble. The rainfall of the previous 24 hours in the Punjab, although general in the northern and eastern districts, was everywhere light. Moderate rain had fallen during the previous 24 hours in Rajputana and Central India, and moderately heavy rain in Bihar and the North-Western Provinces. No rain had fallen in the Central Provinces except a light shower at Seoni.

27th January.—The morning observations of the 27th indicate that the secondary depression in Upper India had filled up and that the primary depression had advanced in a south-east direction into Orissa and the eastern districts of the Central Provinces. The following observations define the position of the central area of the primary depression on the morning of the 27th:—

STATION.	PRESSURE.			WIND.		
	To A.M., reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Mean velocity, previous 24 hours.	Cloud, 10 A.M.
	"	"	"		Miles.	
Vizagapatam	29'932	—'054	—'097	S-W	2	6
Gopalpur	29'902	—'102	—'148	S	17	1
Cuttack	29'924	—'048	—'130	EN-E	3	9
Sambalpur	29'966	—'013	—'053	N-E	10	10
Raipur	29'947	+ '051	—'089	N	10	10
Sironcha	29'949	—'008	—'075	NN-W	2	2

The rise of the barometer in North-Western India varied from '07" in Rajputana to '14" in the North and Central Punjab.

Westerly winds were setting in again over the Gangetic plain. Northerly winds held in Bengal, but contained a strong easterly element due to the influence of the depression. Skies had cleared in Sind, Rajputana and the Punjab, but were more or less clouded in Central and North-Eastern India. Rain had fallen in the North-Western Provinces, Bihar, Chota Nagpur, Orissa, Bengal and Assam, but the amounts were generally under an inch. Hence, although the rainfall was very general to the north and north-east of the central depression, it was light to moderate in amount.

28th January.—During the previous 24 hours pressure had given way rapidly in Burma and South-East Bengal, and was rising in West Bengal and Chota Nagpur. The observations indicate that a shallow depression, the centre of which was in about Lat. 19½° N. and Long. 89½° E., lay over the north of the Bay.

Skies had cleared in the North-Western Provinces, Bihar and West Bengal, but were heavily clouded in East Bengal and Burma. Fairly general rain had fallen during the preceding 24 hours in Assam, Bengal and Orissa. False Point registered the large amount of 3'02 inches.

29th January.—The 10 A.M. observations of this day show that the depression had continued to advance across the Bay and that the centre was now approaching the Arakan coast near Akyab.

The following observations show the character of the disturbance at this stage:—

	BAROMETER.			WIND.		Cloud at 10 A.M.	Rainfall in past 24 hours.
	10 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction, 10 A.M.	Average hourly velocity during past 24 hours.		
	"	"	"		Miles.		Inch.
Diamond Island	30.006	+039	+019	WS-W	5	3	Nil
Thayetmyo	29.983	+059	-018	S-E	8	8	0.07
Toungoo	.990	+053	-007	SS-E	5	10	Nil
Akyab	.999	+095	-020	N-E	4	0	1.04

The barometer was now rising rapidly over the whole of the Indian area, and hence, in the area of depression, pressure was now very slightly below the normal of the period. Skies had cleared in Bengal and were partially clouded in Burma. Some showers had been received during the previous day, chiefly in Arakan, Assam and Central Burma. A rapid increase of pressure occurred over the whole Indian area during the next 24 hours, and the depression either filled up or passed eastwards beyond the Indian area.

The disturbance hence consisted of a primary depression which advanced across the head of the Peninsula and the Bay of Bengal from Sind into Central Burma and of a feeble secondary disturbance in the Punjab.

The following gives the position of the centre of the primary depression at 10 A.M. of each day of its existence in India:—

DATE.	POSITION OF CENTRE AT 10 A.M. OF DATE.		Distance travelled over during previous 24 hours.
	Latitude N.	Longitude E.	
25th	24° 30'	72° 0'	...
26th	22° 45'	79° 15'	475
27th	20° 45'	84° 0'	330
28th	19° 30'	89° 30'	365
29th	18° 45'	94° 0'	290

It hence advanced with a mean velocity of 365 miles per diem from the 25th to the 29th.

The most noteworthy feature of the storm was that it advanced along a track much further south than the mean or normal course of the cold weather storms and in this respect resembled the preceding storm. This, in both cases, was associated with the formation of feeble secondary depressions, and, as will be shown in the concluding discussion

it is very probable that this relation was not accidental but causal. The following gives a brief statement of the rainfall due to the storm:—

DISTRICT.	RAINFALL OF 24 HOURS PRECEDING 6 P.M. OF					Total.
	25th.	26th	27th	28th.	29th.	
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
Punjab.	0'24	0'19	0'01	0	0	0'44
Rajputana	0'17	0'14	0	0	0'03	0'34
Central India	0'03	0'07	0'01	0	0	0'11
North-Western Provinces and Oudh	0'04	0'55	0'10	0	0	0'69
Bihar and Chota Nagpur	0	0'22	0'15	0	0	0'37
Bengal	0'01	0'11	0'41	0'30	0'04	0'87
Assam	0'03	0'09	0'24	0'17	0'17	0'70

At the commencement of the month of February the distribution of pressure was that characteristic of the cold weather, and pressure was absolutely highest at Jacobabad ($30^{\circ}26'$). A very shallow depression apparently lay off the Bombay coast, which advanced into Guzerat on the 2nd. A more important depression appeared on that day to the south of the Sind coast. It covered the sea area to the south of the Sind coast on the morning of the 2nd. and was apparently a very shallow depression. This and the very shallow depression near the Bombay coast combined to give very cloudy weather and general rain on the 2nd and 3rd over the whole of Sind, the Punjab, Rajputana and the North-Western Provinces.

The depression was much less clearly defined on the 3rd, and the winds were very irregular. A rise of the barometer on that day re-established anti-cyclonic conditions in Upper India on the 4th and 5th.

Weather became slightly disturbed again on the North-West frontier on the 9th and 10th, and a very shallow depression lay over Sind on the 11th. It apparently advanced slowly across the head of the Peninsula as a shallow depression of considerable extent. It passed through the Central Provinces on the 13th and 14th, Orissa and South Bengal on the 15th, and was in Burma on the 16th, after which it disappeared. It gave frequent local showers (more especially on the 12th), but the rainfall due to it was throughout small in amount.

Another similar shallow but extensive depression formed on the 15th and 16th in Upper India and advanced eastwards more rapidly than the previous and passed into Burma on the 19th. It gave practically no rain.

A fourth shallow depression appeared in Upper Sind on the 18th. It passed through Rajputana on the 19th, and the North-Western Provinces on the 20th, and filled up on the evening of that day. This feeble storm gave showers, chiefly in the Punjab and North-Western Provinces, and in the northern districts of the Central Provinces.

A fifth depression similar in character to the preceding appeared in Sind and Guzerat on the 24th, and was nearly stationary during the next 24 hours, whilst light showers were falling in Rajputana and Central India. It then advanced eastwards, and was in the Central Provinces on the 26th and Chota Nagpur and Orissa on the 27th. It

filled up during that day, when moderate anti-cyclonic conditions were again established over Northern India.

It may be noted that these depressions were more clearly shown by the barometric changes from day to day than by the actual distribution of pressure. This, of course, arises from the fact that they almost certainly originated at a considerable elevation and moved across Northern India as very shallow depressions (the effect in the lower atmospheric strata being much smaller than at a considerable height). Also at this period of the year in Northern India the gradients are from north to south and are moderately steep. Hence the effect of a very shallow depression is to give uniformity of pressure over the area it traverses in crossing Northern India.

The preceding remarks have shown that a succession of very shallow depressions of peculiar character followed one another across Northern India during the month of February. The following are the most noteworthy points in these feeble storms :—

1st.—During the formation of each storm the largest fall of the barometer occurred in the North Punjab at a considerable distance to the north of the lowest barometer as shown by the observations. These depressions hence almost certainly did not pass into Sind and the Punjab from Baluchistan, but originated in Upper India and were apparently due to actions in the Punjab chiefly.

2nd.—The advance of these depressions was shown by the fall of the barometer in front and rise in rear. The depressions were shallow and the accompanying cyclonic circulations irregular, and hence they are very indistinctly shown in the daily weather charts of the period.

3rd.—Each depression gave cloudy weather in the area over which it extended and to the north of it, more especially in the hill districts, and also more or less rain, chiefly as local showers, in Northern India.

1888-89.

Chief abnormal features of the meteorology of India in 1888.—The hot weather months of April and May 1888 were unusually hot and dry over nearly the whole of India. In May frequent storms occurred in Assam and Bengal and temporary advances of south-west monsoon winds in Tenasserim, Lower Burma and Southern India. These districts received their normal rainfall. Pressure at the commencement of the south-west monsoon was in relative defect in Northern India (especially Burma and Bengal) and in excess in the Peninsula.

The Bombay current set in feebly in the first week of the month. The Bengal current was largely deflected to Burma and was not fully established in Northern India until the last week of the month. Strong and steady monsoon currents prevailed in July and August and gave abundant rain to the greater part of the country. The Bombay current retreated from Upper India in the first week of the month of September. The Bay current showed no sign of weakness until the end of September. A period of fine dry weather prevailed for upwards of a fortnight.

The retreating south-west monsoon current began to give general rain to the Coromandel coast districts on and from the 23rd of October, and shortly afterwards two

cyclonic storms formed, one in the Bay of Bengal and the second in the Arabian Sea, which gave general rain to the whole of India. With the exception of a short break from the 15th to the 24th of November rain continued to fall in Southern India until the middle of December, when very fine weather set in and the north-east monsoon was fully established over the Bay.

The following table gives a summary of the variations of the rainfall from the normal of the two periods of the south-west monsoon :—

METEOROLOGICAL AREA.	PERIOD, JUNE TO SEPTEMBER 1885.		PERIOD, OCTOBER TO DECEMBER 1885.	
	Variation of rainfall from normal.	Percentage variation.	Variation of rainfall from normal.	Percentage variation.
	Inches.		Inches.	
Western Himalayas	+ 3'28	+ 8	+ 0'36	+ 13
Punjab Plains	— 0'84	— 5	— 0'29	— 25
North-Western Provinces and Oudh	+ 10'39	+ 31	— 1'35	— 78
Rajputana	— 3'71	— 18	— 6'06	+ 10
Central India States	+ 2'86	+ 7	— 1'69	— 74
Bihar	+ 4'52	+ 12	— 2'77	— 81
Western Bengal and Chota Nagpur	+ 3'54	+ 8	— 2'89	— 77
Lower Bengal	— 2'77	— 6	— 2'37	— 45
Eastern Himalayas	— 13'19	— 13	— 3'71	— 66
Assam and Eastern Bengal	— 11'23	— 14	— 1'82	— 27
Orissa and Northern Circars	— 6'64	— 18	— 2'06	— 25
Central Provinces, South	— 3'19	— 7	— 1'31	— 45
Berar and Khandesh	— 5'89	— 18	— 1'82	— 44
Guzerat	— 12'92	— 41	+ 0'80	+ 72
Sind and Cutch	— 2'62	— 33	— 0'29	— 91
North Deccan	+ 2'18	+ 11	— 0'98	— 15
Konkan and Ghats	— 0'42	0	— 1'85	— 31
Malabar and Ghats	+ 14'37	+ 16	— 1'83	— 15
Hyderabad	— 7'40	— 29	+ 0'22	+ 5
Ceded Districts and Mysore	— 2'28	— 15	— 0'77	— 9
Carnatic	— 1'12	— 9	+ 2'58	+ 14
Nilgiris	— 3'95	— 27	— 2'04	— 9
Ceylon	— 3'25	— 17	+ 2'67	+ 9
Arakan	+ 17'09	+ 14	— 5'43	— 47
Pegu	+ 10'50	+ 17	— 3'01	— 31
Tenasserim	+ 21'35	+ 15	— 4'00	— 31
Bay Islands	+ 8'65	+ 14	+ 4'90	+ 15

The following gives a brief summary of the antecedent meteorological conditions, which probably influenced the character and distribution of the cold weather storms of 1888-89:—

1st.—The prevalence of a stronger and steadier monsoon current than usual in June, July and August.

2nd.—The unusually early withdrawal of the monsoon currents from North Western India in the beginning of September, which change followed prolonged heavy rain in Rajputana and the North-Western Provinces. The monsoon rainfall was considerably in defect in Western India, Hyderabad, Rajputana, Assam, East Bengal and Orissa, and in large excess in Burma, the North-Western Provinces and Bihar.

3rd.—The retreating south-west monsoon rains were slightly later in commencing on the Madras coast and terminated earlier than usual on the 16th of December. The rainfall of this period was normal in amount and favourably distributed in Madras, Mysore and Hyderabad.

4th.—Pressure in the Indian land area was steadily in excess from September 1888 to August 1889.

The following gives mean variation data for a part of that period:—

1888.				1889.			
September	.	.	+ '037"	January	.	.	+ '020"
October	.	.	+ '039"	February	.	.	+ '024"
November	.	.	+ '010"	March	.	.	+ '053"
December	.	.	+ '026"	April	.	.	+ '012"

5th.—The pressure anomalies were small and apparently of little importance during the period.

The most persistent were—

(a) A slight local deficiency of pressure in Northern India, which was on the whole most marked in Bihar, North Bengal, and Assam.

(b) A slight local excess in the Peninsula which was, on the average of the period, greatest in the Deccan.

6th.—The most remarkable feature in the pressure distribution was a largish and steady deficiency at the hill stations as compared with the neighbouring plains stations. The following gives relative variation data for several pairs of stations:—

YEAR.	MONTH.	VERTICAL PRESSURE ANOMALY.					
		Leh minus Lahore.	Quetta minus Jacobabad.	Murree minus Peshawar.	Simla minus Ludhiana.	Ranikhet minus Bardilly.	Mount Abu minus Deesa.
1888 .	September . . .	— '008	— '028	+ '005	— '055	— '025	— '008
	October . . .	— '004	— '055	— '014	— '047	— '015	+ '014
	November . . .	+ '014	— '037	— '011	— '014	— '010	+ '003
	December . . .	+ '050	— '011	— '018	— '024	— '003	+ '007
1889 .	January . . .	— '014	— '023	— '010	— '008	+ '014	+ '024
	February . . .	+ '060	+ '018	+ '006	— '008	— '008	+ '021
	Mean of period . .	+ '016	— '022?	— '007	— '026(?)	— '008	+ '010

The cold weather season of 1888-89 gave on the whole very favourable rain in Northern India. The earlier part of the season was very dry, but general and heavy rain was received in the last week of January and in February.

During the month of December and the first three weeks of January a series of shallow depressions crossed Northern India from west to east, which gave little or no rain.

During the last week of January and the month of February three depressions or cold weather storms appeared. These gave moderate to heavy general rain, more especially in the Punjab.

The first two of these storms were normal in character. The last storm followed a very unusual course and gave an exceptionally heavy burst of rain to the North Punjab.

The following is a summary of the snowfall information received during this period:—

- (a) The snowfall occurred chiefly during the months of December, January and February, and was not exceptionally large in amount.
- (b) The snowfall in the Afghan highlands was not larger than usual and melted more rapidly than usual in consequence of heavy rain in the last week of February.
- (c) In the Western Himalayas the snowfall was above the average. In the lower ranges it was above the normal but it was rapidly melted by heavy rain in February. In the higher mountain districts it was considerably heavier than usual; and there was a large accumulation of snow lying in March.
- (d) The snowfall was below the normal in the Eastern Himalayas.

The following gives a statement of the variations of the rainfall of the cold weather period from the normal in Northern and Central India:—

Area.	PERIOD 1ST DECEMBER 1888 TO 31ST MARCH 1889.	
	Variation of rainfall of period from normal.	Percentage variation.
	Inches.	
Western Himalayas	+2.47	+ 24
Punjab Plains	+1.80	+ 48
North-Western Provinces and Oudh	+0.89	+ 41
Rajputana	—0.12	— 16
Central India	—0.47	— 29
Bihar	+2.13	+129
Western Bengal and Chota Nagpur	—0.39	— 15
Lower Bengal	—0.64	— 21
Eastern Himalayas	+2.12	+ 51
Assam and Eastern Bengal	—2.07	— 33
Orissa and Northern Circars	—1.62	— 74
Central Provinces, South	—1.59	— 86
Berar and Khandesh	—1.33	— 91
Guzerat	—0.22	— 79
Sind and Cutch	—0.05	— 6

The following gives an account of the more important storms of the cold weather period of 1888-89. They are 8 in number, the tracks of 5 of which are given in the track chart of the season (Plate LVIII).

Disturbance of the 19th to the 22nd November 1888.—18th November.—The barometer had fallen in all districts except the North-West frontier and Baluchistan, where it had risen slightly. Skies were clear except in the North Punjab and Sind, where they were partially clouded.

19th November.—During the next 24 hours the barometer fell over the whole of India. The fall was greatest in the South-East Punjab and adjacent districts and exceeded '1" at the following stations :—

STATION.	Change since previous day.	Variation from normal.
Ludhiana	—'11	—'100
Roorkee	—'11	—'115
Meerut	—'11	—'100
Bareilly	—'11	—'109

Winds were light and very irregular in Upper India and many stations reported calms. Skies were less clouded in the Punjab plains but were overcast in the hills.

20th November.—Pressure had again decreased in all districts. The fall was very unequal in amount and was on the whole least in the area of greatest fall of the previous day and greatest in Baluchistan and Sind. The fall exceeded '1" at the following stations :—

STATION.	Change since previous day.	Variation from normal.
Quetta	—'13	—'209
Jacobabad	—'11	—'205

Pressure was now highest in the Deccan and a shallow depression covered Baluchistan and Sind.

Skies were overcast in the Punjab, North Sind, Baluchistan and the Punjab hills.

Winds were light and unsteady in North-West India and indicated an irregular or imperfectly developed cyclonic circulation over the area of depression. The following gives data for five stations :—

STATION.	WIND.		
	Direction.	Average velocity, past 24 hours.	Normal strength
Kurrachee	E	9	9
Hyderabad	SW	16	6
Jacobabad	SE	1	2
Mooltan	NNW?	1	1
Quetta	Calm	3	3

Snow had fallen at Quetta (1 foot nearly) and at Peshin, and some light showers in the Peshawar, Bannu and Kohat districts.

21st November.—The barometer had risen during the previous 24 hours in all parts of India except the East Punjab, where it fell slightly. The shallow depression now covered the eastern districts, but the winds, as on the previous day, were very light and irregular, *e.g.*:—

STATION.	WIND.		
	Direction, 8 A.M.	Average velocity of preceding 24 hours.	Normal velocity, November.
Dera Ismail Khan	SW	2	1
Mooltan	NNE	3	1
Peshawar	E	5	2
Sialkot	WNW	1	1
Lahore	S	1	1
Ludhiana	E	1	1

These data show that in the Punjab plains winds were very light and exceedingly irregular in direction. The character of the disturbance is however shown by the fact that the average wind velocity at Murree for the day was 22 miles per hour, whereas on the 20th it was only 6 miles. The normal velocity in November (*i.e.*, the average of fine weather and stormy periods) is only 5 miles. At Quetta the wind was at 8 A.M. from north and the velocity 6 miles per hour, whilst at Murree it was from east-south-east.

Moderate to heavy snow had fallen on the Punjab and Kashmir Himalayas and slight snow on the peaks of the Tukhti-i-Sulaiman and fairly general rain over the North and West Punjab. Amounts exceeding one inch were recorded at several stations, including—

Abbottabad	1.70 inches.
Peshawar	1.76 "
Kohat	1.90 "

These facts hence show that the rainy weather with light irregular winds in the North Punjab plains accompanied a strong cyclonic circulation of the atmosphere at a height of 6,000 feet and 7,000 feet, *i.e.*, at the level of Murree and Quetta.

22nd November.—The barometer had risen rapidly over the whole Indian area and anti-cyclonic conditions were again established, which were intensified by a further rise during the next 24 hours, so that on the morning of the 23rd the normal cold weather conditions were apparently established and fine weather with clear skies obtained in all districts except Lower Burma, where some light showers fell.

The track of this shallow depression is not given in the storm track chart of the season.

Shallow depression of the 3rd to the 5th January 1889.—This is another example of the numerous small disturbances which occur in Northern India during the cold weather.

The barometer rose over the whole of India during the 48 hours preceding 8 A.M. of the 2nd, and skies were clear over the whole of India except the north of the Punjab. It then began to fall, the fall being as usual slightly greater in Northern than Southern India, and was absolutely greatest in the South-East Punjab at Roorkee, Ludhiana, Sirsa, Lahore and Sialkot. Rajputana and Central India continued to be the area of highest pres-

sure. No change had occurred in the weather, and winds were very light in Northern India.

4th January.—The barometer changes of the next 24 hours were, in part, the continuation of the general decrease of pressure which commenced on the 2nd, and in part due to the appearance of a disturbance in Baluchistan and the North-West frontier. Over the greater part of India the fall was slightly less than '05". The following gives the changes in the area of depression in North-West India :—

STATION.	PRESSURE.	
	Change in past 24 hours.	Variation from normal.
Mooltan	—'196	—'193
Jacobabad	—'148	—'150
Dera Ismail Khan	—'167	—'168

The centre of the depression was near Mooltan. So far as can be judged from the observations, the depression did not march as a storm across Baluchistan, although it was perhaps the continuation of slightly disturbed weather with rain at Baghdad and Bushire on the 31st December.

The air movement on the Punjab plains was exceedingly feeble. Mooltan, Jacobabad, Lahore, Dera Ismail Khan and Rawalpindi reported calms at 8 A.M. The wind velocity had however increased at Murree from 5 miles on the 2nd to 16 miles on the 4th. The amount of cloud had increased slightly in the Punjab, but skies were clear at Mooltan and Jacobabad. No rain had fallen in Sind during the previous 24 hours.

5th January.—The barometer rose over the whole of India except the south of the Peninsula during the preceding 24 hours. The rise was large in the Punjab and Sind, as is shown by the following :—

STATION.	PRESSURE.	
	Change in past 24 hours.	Variation from normal.
Dera Ismail Khan	+ '137	—'035
Mooltan	+ '154	—'040
Peshawar	+ '129	—'009
Jacobabad	+ '066	—'084

There was a slight local fall at the following hill stations :—

Mussooree	—'012
Simla	—'010

It is hence very probable that the disturbance was propagated almost due eastward during the preceding 24 hours and was advancing across the East Punjab Himalayas and that it had filled up very considerably and was of little or no importance. The chief proof of this is that the wind at Murree had shifted from east-south-east to east-north-east during the previous 24 hours and the wind velocity decreased from 16 miles per hour to 10 miles per hour.

If this be the case it had advanced about 300 miles during the previous 24 hours. Skies were clear except at Simla and the adjacent plains and no rain had fallen on the plains. The great majority of the stations in Upper India reported calms. The barometer also began to rise and normal weather and anti-cyclonic conditions were established over the whole of Northern India on the evening of the 5th.

Shallow depression of the 9th to the 12th January 1889.—The barometer began to fall on the night of the 7th and on the 8th over nearly the whole of India. Skies were at that time clear over the whole of India except in South Madras and Mysore, where some light showers were received. The barometer fell rapidly in North-West India and briskly in North-East and Central India on the night of the 8th and cloud was rapidly developed in North-West India and also in Bengal. The central disturbance at this time appeared, so far as can be judged by the barometric changes at Quetta, Mooltan and Jacobabad, to be in Baluchistan and the South-West Punjab and Upper Sind. Quetta, Simla and all the plain stations in the Punjab except those in the south-east, *viz.* Ludhiana, Sirsa and Delhi, reported calms at 8 A.M. The barometer continued to fall rapidly in the East Punjab and at 8 A.M. of the 10th a shallow depression lay between Sialkot and Ludhiana. Skies had partially cleared in Southern India but were now generally overcast or thickly clouded in the Punjab, Sind and Rajputana. Light rain had fallen at Murree and Quetta.

On the 10th pressure increased in the Punjab and decreased briskly in the North-Western Provinces. Local showers were received in the plains and moderate rain at the hill stations. A heavy fall of snow was received on the higher elevations of the Punjab Himalayas which brought the snow line down to 9,000 feet. At 8 A.M. of the 11th skies were clear in the Punjab and thickly clouded in the North-Western Provinces and Bihar, to which area and the adjacent mountain districts the disturbance was now transferred. With the exception of one or two light local showers the disturbance gave no rain on this day. The barometric changes of the next 24 hours, the clearing of the skies in the North-Western Provinces and a large increase of cloud in North and Central Bengal, indicated that the disturbance had been transferred into the latter area. The depression was much shallower than on the 11th and was evidently filling up. The observations of the 13th gave no evidence of its existence, as fine clear weather prevailed in Bengal, Assam and Upper Burma.

The observations hence appear to establish—

- (a) That the disturbance originated during a period of decreasing pressure in an area of calms in the Punjab.
- (b) The depression was propagated eastwards along the southern base of the Himalayas from the Punjab to North Bengal in about 72 hours and filled up in that area, or in Assam or Upper Burma.
- (c) It gave cloudy weather to the plain districts over which it passed, but no rain (with the exception of a few light local showers of no importance).
- (d) It gave heavy snow to the more elevated districts.

The track of this storm is not given as it is not possible to decide whether this disturbance consisted of a shallow primary and shallow secondary depression during a part of its existence or not. The chief phenomena of the storm are, on the whole, in

favour of the assumption that it was a feeble double disturbance.

Storm of January 28th to February 2nd.—Pressure increased slowly and steadily from the 23rd to the 26th over the whole of India, and on the morning of the 26th was in excess over the whole country. The following gives the variations from the normal on that day—



Central Provinces	+ '065"
Madras	+ '075"
Bombay	+ '050"
Punjab	+ '130"
North-Western Provinces	+ '140"
Bengal	+ '125"
Burma	+ '080"

Average variation of 8 A.M. pressure on 26th from the normal.

Pressure ranged from 30'20" in Assam to 30'00" in South Madras. These strongly marked anti-cyclonic conditions of increased pressure accompanied increased temperature over the whole of India except the North-Western Provinces. Temperature variation data for the 24 hours preceding 8 A.M. of the 26th are given below:—

DISTRICT.	Variation from normal of maximum of 24 hours preceding 8 A.M. of 26th.	Variation from normal of minimum of 24 hours preceding 8 A.M. of 26th.	Variation from normal of mean of 24 hours preceding 8 A.M. of 26th.
Punjab	+2'5	+2'0	+2'3
Sind and Rajputana	+0'4	+6'6	+3'5
Central India	+0'1	+3'5	+1'8
North-Western Provinces	-3'6	+1'9	-0'9
Central Provinces	+2'7	+3'4	+3'1
Bengal	+1'4	+1'8	+1'6
Burma	+2'8	+2'2	+2'5
Madras	+1'4	-0'5	+0'5
Bombay	+1'4	-0'7	+0'4

Winds were very light in Bihar, the North-Western Provinces and the Punjab. Northerly winds prevailed in Bengal, and north-east to east winds in Central India and the Peninsula. Hence the normal circulation of the north-east monsoon obtained over the whole of India and also (as shown by the logs of ships) in the Indian seas.

Notwithstanding the prevalent anti-cyclonic conditions there was much cloud in Baluchistan, Sind, Rajputana, the Punjab, the western districts of the North-Western Provinces and the North-West Himalayas.

No change of importance occurred during the next 24 hours. The barometric changes were small and irregular everywhere, and winds were feeble and very unsteady

n Northern India. The following gives the average air motion of the previous 24 hours :—

AREA.	Average velocity, previous 24 hours, in miles per hour.	Normal average velocity, in miles per hour, January.
Punjab	1'6	1'9
Rajputana	3'0	3'4
North-Western Provinces	1'1	2'2
Bihar	1'7	2'0

Temperature increased somewhat rapidly in the Central Provinces, Central India and Guzerat. The following table gives temperature variation data for the 24 hours preceding 8 A.M. of the 27th :

AREA.	Variation from normal of maximum of 24 hours preceding 8 A.M. of 27th.	Variation from normal of minimum of 24 hours preceding 8 A.M. of 27th.	Variation from normal of mean of 24 hours preceding 8 A.M. of 27th.
Punjab	+1'8	+4'6	+2'9
North-Western Provinces	-3'3	+0'3	-1'5
Bengal and Assam	+1'5	-0'3	+0'6
Central Provinces and Berar	+4'8	+6'4	+5'6
Sind and Rajputana	+1'9	+7'3	+4'6
Guzerat and Central India	+1'8	+7'7	+4'8
Bombay	+2'4	+0'2	+1'3
Madras	+0'7	+0'4	+0'6
Burma	+2'0	+0'5	+1'3

Hence the following conditions obtained immediately previous to the appearance of the disturbance under discussion :—

1st.—Excessive pressure over the whole of India, greatest in Northern India, where the excess ranged from '1" to '15".

2nd.—Excessive temperature over the greater part of the Indian area. This was most marked in a belt of country stretching from Sind through Rajputana and Central India into Berar and the Central Provinces. The mean temperature of the 24 hours preceding 8 A.M. of the 27th was 9° above the normal at Jacobabad, Deesa, Amraoti and Pachmarhi, and 7° above it at Mount Abu. The temperature data of Pachmarhi and Mount Abu show that the excessive temperature was as strongly marked at elevations of 3,000 to 5,000 feet as at the sea-level.

3rd.—Winds were very light and unsteady in Upper India, but in Bengal, Sind, Central India and the Peninsula the normal seasonal winds prevailed.

4th.—Skies had clouded over in Sind and the North Punjab, and were overcast in those areas, as well as in Baluchistan, and cloud was extending eastwards.

28th January.—During the preceding 24 hours the barometer had fallen over the whole

of India. The changes were small except in North-Western India, where the fall ranged from '05" to '12". The fall was absolutely greatest at Quetta in Baluchistan. Pressure was above the average by moderate amounts except in Sind and Baluchistan. The depression was small in Sind, but slightly exceeded a tenth of an inch at Quetta. The following gives barometric and wind data of this shallow depression for 8 A.M., of the 28th :—

STATION.	PRESSURE.			WIND.	
	8 A.M., reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity preceding 24 hours.
Quetta	...	—'140	—'092	EN-E	
Mooltan	30'042	—'120	+ '041	N-W	1
Kurrachee	29'963	—'079	—'026	EN-E	10
Hyderabad	30'001	—'049	+ '004	N-E	11
Jacobabad	30'005	—'089	+ '011	Calm	2

These observations appear to show that a depression was passing through Baluchistan, the centre of which was to the south-east of Quetta. The wind directions at Kurrachee and Hyderabad were, however, as yet not influenced by the depression.

The weather was also apparently disturbed in the extreme north of the Punjab and adjacent hill districts, although pressure was above the normal. Very strong south-east winds (averaging 23 miles per hour) had been blowing at Murree during the previous 24 hours. Skies were overcast over the whole of the Punjab, as well as in Baluchistan, Sind, and the greater part of Rajputana, and were more or less clouded over the whole of Northern and Central India. Light rain showers had fallen at Quetta and in the western and northern districts of the Punjab. Temperature had increased considerably in Bengal, the North-Western Provinces, Bombay, Guzerat and the Central Provinces, and had fallen in the North Punjab and Sind. It was in excess in all districts except North Bihar. The excess was greatest in a narrowish belt stretching from Hyderabad and Rajkote to the eastern districts of the Central Provinces, in which area the excess ranged from 6° to 10½°. It was as large at Mount Abu and Pachmarhi as at the adjacent plain stations.

The following gives data for a few typical stations :—

STATION.	Variation from normal of maximum of 24 hours preceding 8 A.M. of 28th.	Variation from normal of minimum of 24 hours preceding 8 A.M. of 28th.	Variation from normal of mean of 24 hours preceding 8 A.M. of 28th.
Deesa	+6.8	+14.1	+10.5
Mount Abu	+5.7	+ 9.7	+ 7.7
Hoshangabad	+7.1	+ 7.7	+ 7.4
Pachmarhi	+8.6	+ 6.7	+ 7.7
Amraoti	+7.5	+10.8	+ 9.2
Nagpur	+4.6	+ 8.0	+ 6.3
Jubbulpore	+8.7	+ 9.0	+ 8.9
Raipur	+5.2	+ 9.4	+ 7.3
Cuttack	+4.2	+8.0	+ 6.1
Hazaribagh	+5.8	+ 7.4	+ 6.6

The following gives means for the larger provinces :—

PROVINCE.	Variation from normal of maximum of 24 hours preceding 3 A.M. of 28th.	Variation from normal of minimum of 24 hours preceding 3 A.M. of 28th.	Variation from normal of mean of 24 hours preceding 8 A.M. of 28th.
Punjab	-1.6	+8.1	+3.3
Sind and Rajputana	+1.1	+7.1	+4.1
Guzerat and Central India	+5.1	+8.1	+6.6
Central Provinces and Berar	+7.1	+7.5	+7.3
North-Western Provinces	+0.4	+3.0	+1.7
Bengal and Assam	+2.0	+1.8	+1.9
Bombay	+4.4	+1.3	+2.9
Madras	+0.7	+0.8	+0.8
Burma	+2.6	+0.7	+1.7

The air was damper in Sind and the Punjab, but was drier in other districts. The changes were chiefly due to the temperature variations, except in the Punjab.

29th January.—The barometric changes of the previous 24 hours were unusually large and important. Pressure gave way over the whole Indian area (sea and land), the decrease averaging about an eighth of an inch or about $\frac{1}{8}$ of its total amount. If that were due to change in a statical distribution it would be equivalent to the removal of a weight or mass of air of $8\frac{1}{2}$ lbs. for every square foot of surface over an area of at least 2,500 miles long by 2,000 miles, and probably much more, or at least of 500,000,000,000 tons. There had been no increase in the velocity of outflow, in the Bombay or Bengal coast districts, nor were there any indications of outflow across the northern or north-western mountain barriers. Hence, if it were due to outflow, the movement must have been in the upper regions. There is no evidence of this to be found in the observations of the Extra-Indian stations. It is hence almost certain that this diminution of pressure over the whole Indian area must have been due to dynamical causes, and probably to ascensional or expansive movement, common to the whole Indian area.

The fall of the barometer during the previous 24 hours exceeded a tenth of an inch in the Punjab, Sind, Rajputana, Central India and the greater part of the North-Western Provinces and Central Provinces, and was greatest in the North Punjab, where it was nearly three-tenths of an inch. So far as can be judged the changes in Upper India were mainly due to two causes. The disturbance which was passing through North Baluchistan on the previous morning had advanced in an easterly or east-south-easterly direction into Western Rajputana, and given rise to a smallish fall of the barometer in that area and to a corresponding rise in Baluchistan. The disturbance, which was apparently commencing in the North Punjab on the previous day when it was chiefly shewn by the strong winds at Murree, had developed with great rapidity and given rise to a deep depression in the North Punjab, the centre of which was near Rawalpindi and at which pressure was about two-tenths of an inch below the normal. The large decrease of pressure over North-Western India due to this deep depression obscured the smaller depression, and the only evidence of its existence was a peculiar bending of the isobars and of the isabnormals in the chart of the day.

The following gives barometric and wind data of the large depression in the Punjab :—

STATION.	PRESSURE.			WIND.	
	8 A.M., reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity preceding 24 hours.
Simla	...	—'147	—'025	S-E	Miles. ...
Murree	...	—'267	—'199	ES-E	25
Rawalpindi	29'735	—'290	—'185	S-W	3
Sialkot	29'803	—'263	—'172	ES-E	8
Peshawar	29'805	—'293	—'209	W	3
Dera Ismail Khan	29'809	—'232	—'215	WS-W	1
Mooltan	29'802	—'240	—'208	Calm	1

The wind directions show that the centre of the North Punjab depression was north of Rawalpindi and probably at no great distance. The winds were very feeble at all the stations in the North Punjab, and contrast strikingly with the very strong winds prevailing at Murree. The barometer was as low at Dera Ismail Khan as at Peshawar and Mooltan, and the amount of the depression was practically the same at these stations—facts which are satisfactorily explained by the assumption of the existence of the two independent disturbances.

There was a fairly well marked cyclonic circulation in Rajputana. South-west winds obtained at Mount Abu and Neemuch, west winds at Ajmere and Jeypore and north-west winds at Jacobabad. It is noteworthy that north-east winds blew steadily across the Sind and Bombay coasts and also at the head of the Bay. Easterly winds due to the depression in the Punjab were extending rapidly down the Gangetic plain and already prevailed as far east as Bihar.

The temperature conditions at this time were very remarkable. Temperature had decreased in the area of rainfall in the North Punjab, but had increased over the remainder of India and was abnormally high over the whole of Central India and the North Deccan. The mean temperature of the preceding 24 hours was from 10° to 12° in excess in the area represented by the stations of Rajkot, Deesa, Indore, Amraoti, Akola and Khandwa.

The following gives temperature data for the previous 24 hours and cloud data for 8 A.M. :—

STATION OR AREA.		Variation from normal of maxi- mum of 24 hours preceding 8 A.M. of 29th.	Variation from normal of mini- mum of 24 hours preceding 8 A.M. of 29th.	Variation from normal of mean of 24 hours pre- ceding 8 A.M. of 29th.	Cloud at 8 A.M.
HILL STATIONS	Murree	—0'7	—1'7	—4'2	10
	Simla	—1'4	+1'7	+0'2	10
PLAIN DISTRICTS.	Punjab	+0'5	+8'6	+4'6	10
	Sind and Rajputana	0	+8'4	+4'2	4'6
	North-Western Provinces	+1'0	+8'9	+5'0	7'4
	Central India	+7'2	+11'9	4'9'6	1'0

COLD WEATHER STORMS IN INDIA

AREA.	Variation from normal of maximum of 24 hours preceding 8 A.M. of 29th.	Variation from normal of minimum of 24 hours preceding 8 A.M. of 29th.	Variation from normal of mean of 24 hours preceding 8 A.M. of 29th.	Cloud at 8 A.M. of 29th.
Central Provinces	+8.6	+11.0	+9.8	0.3
Bengal	+3.7	+2.9	+3.3	2.7
Burma	+2.5	+2.0	+2.3	1.0
Bombay	+4.7	+2.5	+3.6	0
Madras	-0.5	-1.1	-0.8	1.5

The distribution of cloud, it will be seen, partially explains the temperature features. In the clouded area the night temperature only was excessive; whilst in the dry region of Central India and the Central Provinces, where there was practically no cloud, the day temperature was excessive and the night temperature above the normal by even greater amounts than the day temperature. It is possible, if not probable, that there may have been a very thin veil of cloud at night in those areas which diminished radiation to some extent, and that this effect, added to the high temperature shown by the maximum to have prevailed, combined to give the large night excess of temperature. It is not possible to verify this suggestion in this case in the absence of night observations.

The air was damper at the hill stations and also generally in Sind, Rajputana, the North-Western Provinces and the Punjab, in all of which areas rain had fallen, but was drier in other districts. The following gives a statement of the average changes in this feature:—

PROVINCE.		Change of mean humidity in past 24 hours.
HILL STATIONS	Punjab	+24
	North-Western Provinces	+38
	Rajputana (Mount Abu)	+44
PLAIN DISTRICTS	Punjab	+9
	Sind	+17
	Rajputana	+4
	North-Western Provinces	-2
	Central India	-14
	Central Provinces	-5
	Bihar	-8
	Bengal	Nil

Moderate to heavy general rain fell over the whole of the Punjab and western districts of the North-Western Provinces and scattered showers in Sind and Rajputana. Heavy snow fell in the hill districts.

30th January.—The barometer had again fallen over nearly the whole of India. In Southern, Western and North-Western India the changes were small, nowhere exceeding .05". In Upper India they were large and chiefly due to the further development of the storm which was in the northern angle of the Punjab at 8 A.M. of the previous day.

The central depression (defined by the isobar of 29'65") had moved slowly to the south-east and now covered the eastern districts of the Punjab from Rawalpindi to Ludhiana.

The following gives the 8 A.M. barometric and wind data of the storm area or secondary depression in Upper India:—

STATION.	PRESSURE.			WIND.		
	8 A. M. reduced to sea- level and gravity at Lat 45°.	Change in past 24 hours.	Variation from normal.	Direction, 8 A. M.	Average velocity Previous 24 hours.	
HILL STATIONS—	"	"	"		Miles.	
Mussooree	...	—'271	?	?	?	
Chakrata	...	—'209	—'202	Calm	1	
Simla	...	—'252	—'281	Calm	?	
Murree	...	—'158	—'357	S-E	19	
PLAIN STATIONS—						
INNER AREA	Rawalpindi	29'618	—'159	—'349	Calm	3
	Sialkot	29'636	—'197	—'376	EN-E	6
	Lahore	29'668	—'170	—'364	N-W	5
	Ludhiana	29'640	—'254	—'375	S-W	6
OUTER AREA	Peshawar	29'705	—'136	—'350	W	3
	Dera Ismail Khan	29'672	—'174	—'382	NN-W	2
	Mooltan	29'695	—'143	—'356	Calm	1
	Sirsa	29'690	—'194	—'351	S-W	6
	Delhi	29'747	—'195	—'272	S-E	11
	Roorkee	29'751	—'199	—'264	S	9

Hence the deficiency of pressure in the Punjab to the north of the Sutlej averaged '360" and ranged from '349" at Rawalpindi to '382" at Dera Ismail Khan.

This area of nearly uniform low pressure and of deficiency of pressure hence covered nearly 60,000 square miles, or very approximately the magnitude of England (57,000 square miles). In the normal distribution pressure is always slightly higher in the western than the eastern districts of the Punjab. Hence the apparent depression in the east of the Punjab, shown in the chart of the day was really due to an almost uniform depression extending over the whole province superadded to the normal distribution of the period. Outside this area to the south the amount of the depression decreased rapidly. The isabnormal of '200" ran nearly parallel to that of '35" at a distance of 300 miles approximately, and that of '100" at a distance of about 220 miles from that of '20". This shows a fairly regular decrease at the rate of '10" for 200 miles. Hence the character of the disturbance may be inferred with approximate certainty. It consisted of an almost circular central depression, or more probably elliptical of small eccentricity, the greatest diameter of which ran south-east and north-west. In this central depression, covering an area larger than the whole of England, the depression was very uniform ranging between '35" and '38". Outside this area the storm gradients were very approximately regular (except in one small part of the area referred to below), the rate of decrease of the abnormals being

1" per 200 miles, or, assuming as the unit of gradient '01" per 15 geographical miles (corresponding to one millimetre and one degree), it will be seen that the storm gradients in the southern quadrant were slightly less than 1, and hence were very small compared with the gradients which obtain in the October and November cyclones in the Bay of Bengal, when gradients of as much as 120 have been observed (*vide* Port Blair cyclone of November 1891).

A comparison with the data of cyclonic storms in the United States, the Atlantic Ocean, or in Europe (as an example the cyclonic system shown in the weather chart of the 29th November 1874, given in Scott's Elementary Meteorology, page 357) will show that in many of its important features this cold weather storm in Upper India resembled the cyclonic storms of the Atlantic Ocean and Europe.

Winds were practically unchanged in Burma and the Peninsula. North-westerly winds obtained at Kurrachee and north-easterly to easterly winds on the west coast south of Surat. There was hence no indraught to Upper India from the Arabian Sea in the lower atmospheric strata. Similarly, in the Bay of Bengal north-west winds were blowing at Madras, north winds at Cocanada, north-east winds at Saugor Island and Akyab, and north winds at Diamond Island. There was hence no influx of moist winds from the Bay of Bengal into India at this period.

In Northern India winds were mainly dependent upon the depression in the Punjab. Winds were light in the central depression covering the Punjab, but indicated a feeble cyclonic circulation about a centre between Sialkot and Ludhiana. The feebleness and irregularity of the winds in the Punjab were shown by the fact that Rawalpindi reported a calm at 8 A.M., and Peshawar (in the northerly quadrant) a westerly wind. On the other hand, unusually strong winds had prevailed during the preceding 24 hours in Guzerat, Central India, Rajputana, the North-Western Provinces and Bihar. Meerut, Neemuch and Deesa, for example, reported gales of wind. Hence the strongest winds at this time were experienced in the plains at distances of from 200 to 500 miles from the centre and in the upper strata in the central area at the elevation of Murree, where the average wind velocity of the previous 24 hours was 19 miles per hour.

The air was much drier at 8 A.M. of this day than at the same hour of the preceding day in Sind and the North and West Punjab, and was considerably damper in Central India and Bihar. The air was nearly or quite saturated over a large part of Northern and Central India.

Skies were overcast or heavily clouded in the Punjab, Rajputana, Central India, the North-Western Provinces, Bihar and Assam. They were now clearing in Baluchistan, Sind and the West Punjab. The following table gives humidity and cloud data for Northern India for this day:—

PROVINCE.	Mean cloud, 8 A.M.	Change of mean humidity in past 24 hours.
Punjab	8	—2
Rajputana	8	—12
Central India	6	—12
North-Western Provinces and Oudh	7	+2
Bihar	10	+10
Assam	9	—1

Heavy snow fell over the whole of the Western Himalayas and the Afghan highlands. The snow line was hence brought down to 4,000 from 5,000 feet over the whole of the Western Himalayas west of Mussooree and Chakrata.

Temperature had begun to fall rapidly at the hill stations and in North-Western India, and was already considerably below the average in Sind and the greater part of the Punjab. On the other hand, a considerable increase had occurred in Bengal, Central India and the Central Provinces, and temperature was excessive over a large part of the country. The area of greatest excess had moved eastwards about 350 miles during the previous 24 hours, and now included the stations of Neemuch, Nagpur, Jhansi, Sutna, Jubbulpore, Seoni and Khandwa, or the greater part of Central India and the Central Provinces. The following gives data for these stations:—

STATION.	Variation from normal of maximum of 24 hours preceding 8 A.M.	Variation from normal of minimum of 24 hours preceding 8 A.M.	Variation from normal of mean of 24 hours preceding 8 A.M.	Change in past 24 hours.	AMOUNT OF CLOUD.	
					At 4 P.M. of 30th.	At 8 A.M. of 30th.
Neemuch	+ 8.5	+ 10.2	+ 12.4	+ 3.3	P	2
Jhansi	+ 11.5	+ 10.9	+ 11.2	+ 4.3	P	6
Nowgong	+ 11.5	+ 16.2	+ 13.9	+ 5.9	3	0
Jubbulpore	+ 12.7	+ 17.6	+ 15.2	+ 5.5	4	2
Sutna	+ 13.0	+ 14.7	+ 13.9	+ 8.3	4	2
Seoni	+ 7.8	+ 13.0	+ 10.4	+ 1.3	P	2
Khandwa	+ 11.5	+ 15.4	+ 13.5	+ 1.7	0	0
Indore	+ 6.4	+ 14.9	+ 10.7	- 1.4	P	0

These figures are very interesting as showing the character of the temperature conditions in the warm area advancing eastwards. It will be seen that both the day and night temperatures were largely and almost equally in excess, the excess on the whole being slightly greater in the night than the day temperatures.

The following table gives temperature variation data of Northern and Central India for the previous 24 hours:—

DISTRICT.	Variation of maximum from normal.	Variation of minimum from normal.	Variation of mean from normal.
Punjab	+ 5.5	+ 5.6	+ 0.1
Sind and Rajputana	+ 0.8	+ 6.4	+ 3.6
Guzerat and Central India	+ 7.9	+ 13.9	+ 10.9
North-Western Provinces	+ 1.3	+ 11.4	+ 6.4
Central Provinces	+ 8.5	+ 12.3	+ 10.4
Bengal	+ 5.1	+ 6.4	+ 5.8

A reference to the chart of the day will show that there was a bending of the isobars to the south in Rajputana and Central India. The isobars of 29.75" and 29.80" indicate it clearly. It is almost certain that this was due to the depression which entered

Sind from Baluchistan on the 28th and which the observations of the 31st establish was still in existence. It was almost entirely obscured by the deep depression in the Punjab. In addition, the following are the chief evidences of its existence on this day:—

- 1st.—A larger amount of cloud at Jeypore, Ajmere, Nowgong and Sutna than in the area represented by Jhansi, Agra, and Lucknow.
- 2nd.—The occurrence of moderately heavy rain in Bihar, Chota Nagpur and Rajputana to the north north-east and east of this very shallow depression, whilst little or none fell over the central and eastern districts of the North-Western Provinces. The rainfall was almost certainly due to the shallow depression, and not to the large disturbance in the Punjab which gave rain almost exclusively to the Punjab and the mountain districts to the north and east of the disturbance.
- 3rd.—Calculating the pressure along four lines of stations from the isabnormal of '35", on the supposition of uniform gradients from the central depression southwards in the Punjab, the calculated values agree very approximately with the actual in the case of the eastern and western lines, but in the case of the central lines they differ in such a manner as to show that there was a slight depression in the area represented by the stations of Jubbulpore, Raipur and Indore, *i.e.* in the northern districts of the Central Provinces and adjacent districts of Central India.
- 4th.—It is to some extent indicated in the chart of the day by the steeper gradients to the north of that area and by the diminished gradients to the south and south-east as shown by the peculiar curvature of the isabnormals in the chart showing the pressure variations of this day.
- 5th.—This inference is further confirmed by the fact that there was in this area a slight tendency to a separate cyclonic circulation. It was for obvious reasons less marked in the northern portion of the depression, but the following data will show how far it was true:—

STATION.	Wind.		Normal velocity, January.	Ratio of actual to normal velocity.
	Actual Direction.	Mean actual velocity of previous 24 hours.		
Neemuch	W	19	Miles. 8	Miles. 2.4
Saugor	WS-W	9	3	3
Nagpur	SS-W	11	4	2.7
Jubbulpore	ES-E	8	2.5	3.2
Sutna	S	10	4.5	2.2
Allahabad	E	11	3	3.7
Agra	S-E	11	4	2.7
Jeypore	W	6	4	1.5
Sambhar	S-W	9	5.5	1.6

The previous data establish that to the south and east of this small depression winds were from 3 to 4 times their normal force, whereas to the north, where the air movement

was the resultant of the interfering and opposing cyclonic systems, they were less than twice as strong.

Hence the observations of the day when carefully examined show that the slight depression which entered Sind before the deep depression in the Punjab began to be exhibited was still in existence. It almost certainly occupied the northern districts of the Central Provinces and the adjacent districts of Central India, and was hence about 700 miles to the west of its position on the 28th, when it was in Sind. The rainfall of Bihar, the eastern districts of the North-Western Provinces, Rajputana, and some parts of Central India, was most probably chiefly, if not entirely, due to this disturbance, and not to that in the Punjab.

31st January.—During the previous night pressure increased very rapidly over the whole of North-Western India, and the 8 A.M. observations indicated that the depression which overlay the Punjab and the North-West Himalayas had almost entirely filled up. The following gives barometric and wind data of the more important stations in the Punjab and North-Western Provinces:—

STATION.	PRESSURE.			WIND.	
	8 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity pre- ceding 24 hours.
Peshawar	29'916	+ '247	— '122	E	5
Lahore	29'884	+ '255	— '125	E	1
Delhi	29'897	+ '196	— '094	S	3
Bareilly	29'882	+ '153	— '089	Calm	2
Lucknow	29'885	+ '067	— '096	Calm	6
Benares	29'859	+ '026	— '117	Calm	9

These observations show that the rise was greatest in the Punjab and diminished in amount eastwards and southwards, and that over the whole of Upper and Central India pressure was almost uniformly about a tenth of an inch below the normal. The only evidence (and it is somewhat doubtful) of the eastward transmission of the disturbance shown on the 30th in the Punjab is afforded by the observations at the hill stations. They are given below:—

STATION.	PRESSURE.			WIND.	
	8 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity pre- ceding 24 hours.
Murree	23'653	+ '202	— '154	S-E	15
Simla	23'048	+ '134	— '150	S-E	?
Mussooree	23'416	+ '140	?	?	?
Ranikhet	23'947	+ '026	— '136	Calm	4

Mussooree is about 380 miles in a direct line from Murree and 90 miles from Ranikhet. The small rise at Ranikhet, compared with other stations, if accepted (and it is confirmed by other evidence) would appear to indicate that the breaking up of the large disturbance

in the Punjab was followed by the transmission of a small disturbance along the Himalayan mountain region. The barometer had fallen during the previous 24 hours in North-Eastern India, briskly in North Orissa and the greater part of Bengal and slightly elsewhere. A shallow depression now covered Chota Nagpur, Orissa and South-West Bengal, which was almost certainly the continuation of the very slight depression in the northern districts of the Central Provinces on the previous day. The following table gives barometric and wind observations of this area :—

STATION.	PRESSURE.			WIND.	
	8 A.M., reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity, preced- ing 24 hours.
Saugor Island	29.888	—106	—109	S	Miles. 17
Burdwan	29.888	—093	—125	S	4
Purnea	29.918	—084	—089	EN-E	4
Gaya	29.907	—058	—117	EN-E	8
Hazariabagh	29.892	—067	—125	S-W (?)	18
Raipur	29.903	—010	—082	WS-W	12
Vizagapatam	29.937	—050	—050	W	1?
Gopalpur	29.891	—079	—078	S-W	25

These data show the position and character of the depression. A fairly complete circulation was established, and strong winds were blowing in the south-east quadrant at Saugor Island, False Point and Gopalpur. To the north-west of the depression, in the North-Western Provinces, all the stations except the most westerly had calms at 8 A.M. The depression was about 350 to 400 miles east of the position found for the slight depression in the Central Provinces on the 30th, a strong proof that it was the continuation of that depression.

The air was much drier in North-West India, and skies were clear at 8 A.M. in Sind, Rajputana, Central India and the Central Provinces, and were lightly clouded in the Punjab. They were overcast in Assam, West Bengal, Bihar and the eastern districts of the North-Western Provinces, and were clear over the whole of Burma.

The following table gives comparative data of humidity and vapour tension for 8 A.M. :—

PROVINCE.	Change of humidity in previous 24 hours.	Change of aqueous vapour pressure in previous 24 hours.
Punjab	—1	—033
Sind and Rajputana	—5	—069
North-Western Provinces	+3	—048
Central India	+3	—112
Central Provinces	—	—101
Bihar	+5	+046
Bengal	+1	+030

Rain fell generally during the previous 24 hours in the greater part of the Punjab and North-Western Provinces, but the amounts received were in no case large. Some light local showers fell in Rajputana and Central India. Bihar, Chota Nagpur and North Bengal, on the other hand, received moderate to heavy rain. Hence the rainfall in the shallow depression was almost wholly in the northern quadrant at a considerable distance from the central depression.

Temperature had fallen very rapidly during the previous 24 hours in the North-Western Provinces, the North Deccan, the Central Provinces, Guzerat, Central India, Rajputana, Sind and Bihar. The reduction of temperature exceeded 10° at many stations in these districts and amounted to 14° at Ajmere, where it was greatest. Temperature was now below the normal in North-Western India, but was considerably above it in Central and North-East India. The areas of greatest excess of temperature were Upper Burma, Assam, Orissa and the Central Provinces. The following gives data for a few representative stations:—

STATION,	Variation from normal of maximum of 24 hours preceding 8 A.M. of 31st.	Variation from normal of minimum of 24 hours preceding 8 A.M. of 31st.	Variation from normal of mean of 24 hours preceding 8 A.M. of 31st.
Sibsagar	+6.1	+ 8.5	+7.3
Silchar	+6.6	+ 7.5	+7.1
False Point	+3.2	+13.9	+8.6
Raipur	+7.2	+ 7.4	+7.3

During the preceding 24 hours heavy snow had fallen in the Western Himalayas, and hence temperature was remarkably low at the hill stations, as is shown by the following data:—

STATION,	Maximum of 24 hours preceding 8 A.M. of 31st.	Variation from normal.	Minimum of 24 hours preceding 8 A.M. of 31st.	Variation from normal.	Mean.	Variation of mean from normal.
Quetta	35.4	-13.2	26.3	-2.3	30.9	-7.8
Murree	32.6	-13.1	26.7	-6.5	29.7	-9.8
Srinia	39.5	-9.3	24.0	-9.7	31.8	-9.5
Mussooree	34.0	?	28.0	?	31.0	?

The mean temperature of the previous 24 hours at all these stations was hence to a moderate extent below the freezing point.

The following table gives temperature variation data for Northern and Central India for the past 24 hours:—

PROVINCE.	Variation from normal of maximum of 24 hours preceding 8 A.M. of 31st.	Variation from normal of minimum of 24 hours preceding 8 A.M. of 31st.	Variation from normal of mean of 24 hours preceding 8 A.M. of 31st.
Punjab	-6.1	+1.7	-2.2
Sind and Rajputana	-5.5	+2.2	-3.9
Guzerat and Central India	-1.3	+4.0	+1.4
North-Western Provinces	-3.0	+6.2	+1.6
Central Provinces	+4.1	+6.6	+5.4
Bengal	+0.9	+7.4	+4.2

1st February.—The barometer had fallen briskly in Assam and rapidly in Upper Burma during the previous 24 hours, and the depression which was in Bengal on the 31st had advanced into Upper Burma during the day. The following gives barometric and wind data of the area of depression:—

STATION.	PRESSURE.			WIND.		Cloud at 8 A.M.
	8 A.M. reduced to sea-level and gravity at Lat. 45°	Change in past 24 hours.	Variation from normal.	Direction 8 A.M.	Average hourly velocity preceding 24 hours.	
Sibsagar	29'930	—'094	—'115	Calm	1	Miles. 10
Mandalay	*29'601	—'137	?	S.W	?	0
Bhamo	*29'397	—'168	?	S.E	8	0
Kindat	*29'652	—'087	?	Calm	2	0
Silchar	29'881	—'053	—'135	Calm	3	10
Chittagong	29'883	—'058	—'119	Calm	5	9
Akyab	29'931	—'020	—'051	EN-E.	2	7

* Not reduced to sea-level, as elevations have not yet been determined.

The preceding data show the existence of the depression very clearly. The winds were very light and furnish no evidence of a defined cyclonic circulation.

The barometer had risen rapidly in North-Western India and briskly in Upper India. Pressure was now slightly above the normal over the whole of India to the west of Long. 78° E. Hence the ordinary anticyclonic conditions of the period were again established in Upper India. The deficiency to the east of Long. 78° E. was greatest in the shallow depression in Upper Burma and Assam, where it probably slightly exceeded a seventh of an inch. A reference to the chart of isabnormals for the day will show a considerable local deficiency in the most eastern districts of the North-Western Provinces. The isabnormals are packed closely together in the eastern districts of the North-Western Provinces, whilst they are widely apart in Bihar.

It is almost certain that this was an indication of the existence of a very slight disturbance propagated eastwards along the Himalayan mountains, and which was probably passing through Kumaon and Garhwal on the 31st.

Westerly winds were re-established over the whole of Northern India during the previous 24 hours. Moderately strong north-west winds were blowing in Bengal in the western out-skirts of the depression.

The air was much drier at 8 A.M. in the Punjab, Rajputana, the North-West Provinces, Central India, the Central Provinces and the North Deccan, and skies were generally clear in these districts. Skies were overcast in Assam and East Bengal, but were clear in Burma.

Rain had fallen in moderate amounts in Assam, and North and East Bengal during the preceding day. Snow had continued to fall in the Western Himalayas until the afternoon of the 31st, when the weather cleared up rapidly.

Temperature had fallen rapidly in the Punjab, the North-Western Provinces, Bihar, Assam, the Central Provinces, Central India, and Rajputana, and the mean temperature of the previous 24 hours was more or less in defect in these districts. The deficiency

was greatest in Rajputana and Central India, in which it ranged from 4° to 6° . Temperature was considerably above the average in North-Eastern India, the area of the greatest excess of temperature including East Bengal, Cachar, and probably Upper Burma, in which the excess ranged from 5° to 8° .

Very low temperatures were observed at the hill stations in Upper India, as is usual in the later stages of a heavy snow-storm. The following gives data for two stations in illustration:—

STATION,	Maximum of 24 hours preceding 8 A.M. of 1st,	Variation of maximum from normal,	Minimum of 24 hours preceding 8 A.M. of 1st,	Variation of minimum from normal,	Mean temperature of previous 24 hours,	Variation of mean temperature from normal,
	°	°	°	°	°	°
Murree	34.1	-11.4	23.7	-9.0	28.9	-10.2
Simla	28.8	-20.0	21.0	-13.1	24.9	-16.6

Both day and night temperatures were hence largely reduced below the normal at the hill stations.

The following gives temperature variation data of the previous 24 hours for Northern and Central India:—

AREA.	Variation from normal of maximum of 24 hours preceding 8 A.M. of 1st,	Variation from normal of minimum of 24 hours preceding 8 A.M. of 1st,	Variation from normal of mean of 24 hours preceding 8 A.M. of 1st,
	°	°	°
Punjab	-5.9	-0.9	-3.4
Sind and Rajputana	-4.6	+1.3	-1.7
Guzerat and Central India	-4.7	-1.9	-3.3
North-Western Provinces	-3.4	+0.4	-1.5
Central Provinces	-3.9	-4.0	-4.0
Bengal	+0.2	+6.8	+3.5
Burma	+4.8	+3.3	+4.1

These figures illustrate very clearly the cooling effect which follows the clearing of the skies and setting-in of strong westerly winds after the passage of these cold weather storms. The reduction is almost entirely in the day temperature, as the same strong winds which cool the air by day continue during the night (although weaker than by day) and hence do not permit that accumulation or diminution of temperature in the lowest strata, such as occurs on perfectly still nights in Northern India in the cold weather. On the other hand, the increased temperature in the cloud area, *e.g.*, Bengal and Assam, was almost entirely in the night temperature, and hence due to decreased radiation. In Burma, on the other hand, which was in front of the storm area during the preceding 24 hours, both day and night temperatures were almost equally exaggerated.

2nd February.—During the preceding 24 hours pressure increased rapidly in East Bengal and slightly in Upper Burma. The depression, which was passing through that area on the previous day, gave slight indications of its existence and had apparently passed

eastwards into Siam, or was breaking up in the hills separating these two areas. The following gives barometric and wind data for 8 A.M. of this day :—

STATION.	PRESSURE.			WIND.	
	8 A.M. reduced to sea- level and gravity at Lat. 45°.	Change from past 24 hours.	Variation from normal.	Direction. 8 A.M.	Mean velocity previous 24 hours.
Sibsagar	30'080	+150	+031	S-W	Miles. 3
Silchar	30'015	+134	—002	S	5
Chittagong	30'011	+128	+006	Calm	2
Kindat	...	+001	?	Calm	1
Bhamo	...	+006	?	Calm	8
Mandalay	...	+001	?	Calm	8
Toungoo	29'908	—009	—053	Calm	1
Thayetmyo	29'892	—028	—056	S-W	6

The barometer had fallen in North-Western India. The changes brought into prominence the very slight depression and disturbance which had been advancing eastward over the Himalayan area during the previous 24 hours. The following gives data :—

STATION.	PRESSURE.			WIND.	
	8 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Mean velocity previous 24 hours.
Darjeeling	...	+024	?	EN-E	Miles. 5
Purnea	29'959	+066	—052	S-W	10
Patna	29'971	+028	—059	W	7
Darbhangha	29'935	—015	?	WS-W	12
Gorakhpur	29'936	+007	—080	W	5
Benares	30'003	+017	—026	W	8

Skies were clear in the whole of this area, except at Darjeeling, where they were clouding over. The observations establish the existence of the small depression, deepest at Darbhanga and Gorakhpur, whilst the wind directions show that there was a tendency towards cyclonic circulation over this area, the wind direction at Darjeeling indicating that the cyclonic circulation was probably continued to an elevation of 10,000 feet at least. Darjeeling reported a strong wind and Darbhanga a gale of wind. This slight depression and disturbance filled up during the next 48 hours.

The disturbance extending from the 28th January to the 2nd of February was a remarkable one, as it consisted of two apparently independent depressions, one shallow but long-lived, and the other deep, but of brief existence.

The first disturbance passed from Baluchistan into Sind on the 28th. The central depression was in West Rajputana in about Long. 74° E. on the morning of the 29th, in the northern districts of the Central Provinces (about Long. 79° or 80° E. on the 30th, in Long. 85° or 86° E. on the 31st in Long. 92° or 93° E. on the 1st and

in Long. 98° E. on the 2nd, when it was probably filling up. The depression was thus in existence for at least six days and travelled across Northern India at a rate of about 400 miles per diem. The depression at the centre of the disturbance was throughout small, and was probably somewhat larger in Bengal than when passing through Central India. It almost certainly never exceeded a seventh of an inch. It was hence throughout a shallow depression.

The second and shorter-lived depression appeared in the north of the Punjab on the morning of the 29th. In the absence of data for Turkestan it cannot be stated with certainty that it did not pass into the Punjab from Afghanistan or Turkistan; but, considering the characteristic features of the storm and the elevation and extent of the mountain region to the north and north-west of Kashmir and the Peshawar and Hazara districts, it is most probable that it formed in the North Punjab.

It advanced slowly to the south-east along the southern face of the Punjab Himalayas for about 48 hours, giving very heavy snow in the mountain districts and heavy rain in the Punjab (chiefly in the eastern districts) and filled up on the evening of the 30th and morning of the 31st with great rapidity. So far as can be judged from the observations, a small residual depression passed eastwards along the Himalayas, which gave snow and strong winds at Darjeeling (or in Sikkim) on the 2nd. The evidence for this is very limited, since there is absolutely no information for the whole of the Central Himalayan region between Kumaon and Sikkim.

The temperature changes which accompanied this double storm were very strongly marked. The more important were—

(a) High or excessive temperature in front of the storm. There was what may be described as a warm wave in front of the storm. This high temperature was in part the product of the antecedent fine clear weather, and in part probably to a thin veil of cloud extending to a considerable distance in front of the depression area. This thin veil exercises hardly any effect in diminishing solar radiation at the earth's surface, whilst it is very effective in diminishing radiation at night from the earth's surface.

(b) Low temperature in the area of rainfall and to the north-west of the storm area. Full data have been given of these features in the discussion.

The following gives a statement of the rainfall during the storm in Northern India :—

PROVINCE.	RAINFALL OF 24 HOURS PRECEDING 6 P.M. OF THE						
	28th January.	29th January.	30th January.	31st January.	1st February.	2nd February.	TOTAL.
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inches.
Punjab	0·33	0·92	0·78	0·14	0·07	0	2·24
Rajputana	0·04	0·11	0·05	0	0	0	0·20
Central India	0	0	0·05	0·01	0	0	0·06
Central Provinces	0	0	0	0	0	0	0
N.-W. Provinces	0·01	0·19	0·54	0·17	0	0	0·91
Bihar	0	0·03	0·98	0·38	0	0	1·39
Bengal	0	0·04	0·28	0·33	0·10	0	0·75
Assam	0	0	0·07	0·91	0·39	0·01	1·28

Storm of February 5th to 7th.—After the disappearance of the previous storm, pressure increased rapidly, and was very high in Upper India from the 1st to the 4th, on which day it was nearly two-tenths of an inch above the normal in the Punjab. The barometer then began to fall rapidly in the Punjab and Sind. The changes elsewhere were small and irregular, except in Burma, where pressure was increasing briskly. The most important feature in the distribution of pressure was a shallow depression which overlay the central Himalayan region. The variations of the mean temperature of the 3rd from the normal were as follows :—

Rajputana	—6°0	Bengal	—2°0
North-Western Provinces	—5°0	Burma	+1°3
Punjab and Sind	—4°0	Madras	+1°5
Central Provinces	—2°0	Bombay	+1°5

Strong westerly winds blew down the Northern India plain, and northerly winds set in over Bengal, replacing the calms which had prevailed for 48 hours. A general decrease of humidity hence occurred over the whole of this region, which was greatest at the hill stations. The following table gives data :—

STATION OR DISTRICT.	HUMIDITY.		
	S A.M. of 3rd.	S A.M. of 4th.	Change.
Murree	% 84	% 26	—58
Quetta	92	55	—37
Ranikhet	87	48	—39
Simla	42	58(?)	+16(?)
Punjab	83	74	—9
North-Western Provinces	80	69	—11
Bihar	76	68	—8
Bengal	81	78	—3

Skies were free from cloud over almost the whole of India.

5th February.—During the next 24 hours pressure increased in Northern India, and the low pressure area which covered the Central Himalayas filled up. A further rapid fall of the barometer had occurred in Baluchistan and Sind, and a well-marked depression now covered that area. The following are the 8 A.M. observations at stations in and near the depression area :—

STATIONS.	PRESSURE.			WIND.		Cloud, 8 A.M.
	8 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity preceding 24 hours.	
Quetta	"	"	"		Miles.	
Jacobabad	29°972	—°134	—°013	W	1	8
Hyderabad	29°977	—°148	—°099	N-E	2	8
Kurrachee	29°977	—°155	—°084	S-W	15	0
	30°002	—°145	—°053	W	12	0

There was hence a feeble cyclonic circulation in the area of depression in Sind. It did not, however, extend to Quetta (where winds were westerly), the Punjab (where the winds were very irregular), Rajputana, Kathiawar or Guzerat (where they were from north-east).

A rapid increase of temperature had taken place to the north and east of the depression. The following gives the variations of the mean temperature :—

DISTRICT.	Variation of mean temperature from normal.	Change during previous 24 hours.
North-Western Provinces	—5°0	0
Bengal	—4°0	—2°0
Central Provinces	—4°0	—2°0
Sind	—0°7	+3°9
Punjab	—2°0	+2°0
Rajputana	—3°5	+2°5

Westerly winds continued in the Gangetic plain, but they were much feebler than on the 4th. Humidity had increased considerably in the Punjab, Sind, Rajputana and the North-Western Provinces, and decreased in other districts.

Skies were slightly clouded in North Sind and Baluchistan, but were free from cloud in all other districts of Northern and Central India.

6th February.—The only important barometric changes of the preceding 24 hours comprised—

1st.—A brisk rise in Sind and Baluchistan.

2nd.—A brisk fall in Rajputana and the western districts of the North-Western Provinces.

Skies had partially clouded in Rajputana and the western districts of the North-Western Provinces, but were clear in all other districts, except Southern India, where weather was fine with passing clouds.

It is hence almost certain that the disturbance which was in Sind on the previous morning had travelled eastwards. The following gives 8 A.M. observations at stations in the area of depression :—

STATION.	PRESSURE.			WIND.		Cloud, 8 A.M.
	8 A.M. reduced to sea- level and gravity at lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Mean velocity of previous 24 hours.	
					Miles.	
Roorkee	30°091	—°100	+°051	E	2	8
Delhi	30°057	—°087	+°014	E	5	7
Jeypore	30°051	—°073	—°011	E	6	3
Ajmere	30°059	—°097	—°032	Calm	2	2
Jhansi	30°065	—°056	+°025	Calm	1	0
Nowgong	30°072	—°061	+°014	N	1	0

A rapid increase of temperature had taken place in Sind, Rajputana, Guzerat, and Central India. The following gives the variations of the mean temperature of the previous 24 hours from the normal :—

DISTRICT.	Variation of mean temperature from normal, -	Change in past 24 hours.
Sind	0 +5.5	0 +6.2
Rajputana	+5.0	+8.5
Punjab	-1.0	+1.0
North-Western Provinces	-2.5	+2.5
Bihar	-4.5	+1.1
Bengal	-3.0	+1.0
Madras	+2.0	+0.6
Bombay	+1.5	+0.5

A rapid increase of humidity had occurred in Central India and Rajputana. Elsewhere the changes were slight. Quetta reported a light shower.

7th February.—Pressure increased in West and North-West India during the previous 24 hours, and fell in Central and North-East India. The fall was greatest at Gorakhpur, Allahabad, and Benares, but was less than '06" at these stations. The disturbance had hence continued to march eastwards, but it had filled up partly, and was of less importance than on the previous day. Skies were partially clouded over the whole of the North-West Provinces and in the Punjab, but were clear in other districts of Northern and Central India. A rapid decrease of humidity had taken place in Sind and West Rajputana. Winds were now very light and irregular over the whole of Northern India. Northerly winds continued in Bengal, but they were very unsteady.

Temperature was now falling in Sind and Madras, but had increased in all other districts, rapidly in the Central Provinces, Central India, Rajputana and the North-Western Provinces, and moderately elsewhere. The following gives the variations of the mean temperature of the past 24 hours from the normal :—

DISTRICT.	VARIATION FROM NORMAL OF			Change in past 24 hours.
	Maximum of 24 hours preceding 8 A.M. of the 7th.	Minimum of 24 hours preceding 8 A.M. of the 7th.	Mean of 24 hours preceding 8 A.M. of the 7th.	
Punjab	+1.7	+4.6	+3.2	+4.0
Rajputana and Sind	+5.1	+5.7	+5.	0
Guzerat and Central India	+4.5	+3.4	+4.0	+2.0
Central Provinces and Berar	+5.5	+3.7	+4.6	+5.0
North-Western Provinces	-0.3	+2.3	+1.0	+3.8
Bengal and Assam	-1.9	-1.5	-1.7	+2.0
Burma	-0.6	-0.7	-0.7	+1.5

The disturbance passed eastwards during the next 24 hours into North Bihar and Bengal, but was of no importance. Skies partially clouded over in that area and Assam, but on rain fell, and winds were light throughout. The depression filled up during the day, and normal pressure conditions obtained in North-Eastern India on the 9th.

The following state the more important features of the very shallow depression and feeble disturbance described :—

1st.—It appeared in Sind on the 5th and travelled across Northern India into Bengal, with an average velocity of about 350 miles *per diem* and filled up in North Bengal.

2nd.—The observations appear to establish that the depression formed in Sind on the evening of the 4th. The following table giving the variations of the barometer from the normal at Quetta, Jacobabad and Kurrachee on the 3rd, 4th and 5th, it will be seen, fully supports this conclusion :—

STATION.	Hour.	VARIATION OF PRESSURE FROM NORMAL ON THE		
		3rd.	4th.	5th.
Quetta	8	+ '152	+ '128	— '013
	10	+ '121	+ '094	— '056
	16	+ '110	+ '052	— '005
Jacobabad	8	+ '178	+ '046	— '099
	10	+ '204	+ '055	— '075
	16	+ '194	— '003	— '055
Kurrachee	8	+ '165	+ '090	— '053
	10	+ '169	+ '101	— '053
	16	+ '168	+ '039	— '042

3rd.—It gave cloudy weather over the north and north-eastern portion of the shallow depression and some light showers, chiefly in the hill districts. The weather in the southern and central portion of the depression was throughout fine and skies clear.

4th.—The most striking feature of the storm was the remarkable temperature conditions to which it gave rise. Immediately in front of the depression temperature was very largely in excess of its normal value, whilst over the western half of the depression area, and for a considerable distance to the west, temperature was more or less considerably below the average. Hence the depression was apparently preceded by a warm wave and followed by a cool wave, which of course advanced practically at the same rate as the depression.

The following table gives the variations of the mean temperature of the day from the normal during the period 3rd to the 8th in Northern and Central India :—

DISTRICT.	VARIATION OF MEAN TEMPERATURE ON THE					
	3rd.	4th.	5th.	6th.	7th.	8th.
Punjab	—6°1	—4°0	—1°6	—0°3	+3°2	+3°3
Sind and Rajputana	—6°4	—5°7	—0°3	+5°0	+5°4	+4°0
Guzerat and Central India . .	+0°5	—4°4	—2°4	+1°8	+4°0	+7°7
Central Provinces and Berar . .	+1°8	—2°1	—4°3	—1°2	+4°6	+7°6
North-Western Provinces . . .	—4°2	—5°2	—5°1	—2°3	+1°0	+3°6
Bengal and Assam	—3°3	—2°4	—4°3	—3°2	—1°7	+2°0
Burma	+1°3	+0°5	+0°4	—1°5	—0°1	+0°1

An inspection of the preceding data shows that the temperature changes accompanying these storms are large and rapid. The wave was transmitted eastwards from the Punjab and Rajputana on the 3rd to Burma on the 6th at a rate of about 300 to 400 miles *per diem*.

These changes in a small portion of the area were due in part to cloud and rain, but in the greater portion of the area of depression there was no cloud throughout, as is shown by the following data :—

PROVINCE.	AVERAGE CLOUD AMOUNT.					
	3rd.	4th.	5th.	6th.	7th.	8th.
Punjab	0	2'4	1'8	3'4	4'9	0'3
Rajputana	0	0	0	2'5	0'7	0
North-Western Provinces	1'4	0	1'1	2'8	2'0	0
Bihar	7'5	0	0	0	0	0
Bengal	0'3	2'8	0'9	0'8	1'0	1'4

5th.—The winds were throughout very light and unsteady in the area of disturbance and shallow depression. They, on no day except the 5th, constituted a clearly defined cyclonic circulation in the lower strata near the earth's surface.

The following table gives the average velocity of the winds at six representative stations in illustration of the above :—

STATION.	4TH.		5TH.		6TH.		7TH.		8TH.		Mean average hourly velocity preceding 24 hours.
	Direction.	Average hourly velocity preceding 24 hours.	Direction.	Average hourly velocity preceding 24 hours.	Direction.	Average hourly velocity preceding 24 hours.	Direction.	Average hourly velocity preceding 24 hours.	Direction.	Average hourly velocity preceding 24 hours.	
		Miles.		Miles.		Miles.		Miles.		Miles.	Miles
Jacobabad	Calm	1	N-E	2	Calm	3	NN-W	2	E	2	2
Deesa	NN-E	12	N-E	6	* S	6	NN-E	9	NN-E	13	9
Jeypore	NN-E	4	E	5	E	6	ES-E	5	NN-E	5	5
Allahabad	W	8	Calm	5	Calm	1	Calm	1	WN-W	3	3'6
Patna	W	6	N-E	3	S-W	1	S-W	1	S-W	2	2'6
Burdwan	N	1	Calm	2	Calm	1	N	1	Calm	1	1'2

The preceding remarks have, it may be noted, shown that the temperature changes which accompanied the storm were not due to cloud, as they were as marked in the area of clear skies to the south as in the cloudy districts to the north. They were also not due to rainfall, as practically none occurred in the plain districts.

Depression of February 15th to 21st.—After the dispersion of the preceding depression, pressure increased on the 12th and 13th over the whole of India, and on the morning of the 14th was above the average of the day by amounts ranging from '06" at

Colombo in Ceylon and Diamond Island in Burma to '13" in Upper Assam and the western districts of the North-Western Provinces. The excess was, even, greater at the hill stations in Upper India, amounting to '16" at Murree and to '18" at Quetta.

The temperature conditions were such as usually obtain during the prevalence of the anti-cyclonic conditions in Upper India which immediately precede the appearance of a depression, excessive temperature accompanying excessive pressure. The following table gives the temperature and pressure variations in different parts of the country :—

PROVINCE.	Mean variation of pressure from normal on 14th February.	VARIATION FROM NORMAL OF		
		Mean maximum temperature of 24 hours preceding 8 A.M. of 14th.	Mean minimum temperature of 24 hours preceding 8 A.M. of 14th.	Mean temperature of 24 hours preceding 8 A.M. of 14th.
Punjab	+123	+5'4	+0'1	+2'8
Sind and Rajputana	+098	+3'5	+4'9	+4'2
Guzerat and Central India	+110	+4'2	+3'2	+3'7
North-Western Provinces	+130	+2'4	+2'1	+2'3
Central Provinces and Berar	+100	+1'8	+1'1	+1'5
Bengal and Assam	+117	0	+1'3	+0'7
Burma	+070	-0'3	+2'1	+0'9
Bombay	+073	+3'2	+0'2	+1'7
Madras	+086	+0'4	-0'2	+0'1

The air was slightly drier on the 14th than on the 13th, and there was practically no cloud anywhere except at the hill stations and in Southern India, where the weather was reported to be fine with passing clouds.

15th February.—The barometer fell over the whole of India during the preceding 24 hours, but the only important changes occurred in Baluchistan and Upper Sind, where it had fallen rapidly. A very shallow depression covered Sind, in which pressure was '02" below the normal.

Temperature increased over the whole of India except South Madras, and the variations from the normal were excessive. The following gives data for the 24 hours preceding 8 A.M. of the 15th :—

PROVINCE.	Variation from normal of maximum temperature of 24 hours preceding 8 A.M. of 15th.	Variation from normal of minimum temperature of 24 hours preceding 8 A.M. of 15th.	Variation from normal of mean temperature of 24 hours preceding 8 A.M. of 15th.
Punjab	+7'0	+6'8	+6'9
Sind and Rajputana	+5'7	+6'7	+6'2
Guzerat and Central India	+6'1	+3'5	+4'8
North-Western Provinces	+3'0	+2'2	+2'6
Central Provinces	+4'8	+2'4	+3'6
Bengal	+2'3	+1'9	+2'1
Burma	+0'7	+1'3	+1'0

The excess was absolutely greatest at Mooltan and Jacobabad, where the mean temperatures were 10.4° and 9.8° in excess respectively.

A considerable increase of humidity had occurred at the hill stations and in Sind, but in Rajputana, the Punjab and Guzerat there was a marked decrease.

The following gives data :—

STATION OR DISTRICT.		HUMIDITY.	
		8 A. M.	Change in past 24 hours.
HILL STATIONS	Quetta	88	+18
	Murree	73	+41
	Simla	67	+16
	Ranikhet	84	+22
	Mount Abu	32	+ 5
PLAIN STATIONS OR DISTRICT	East Punjab	75	— 5
	Rajputana	58	—17
	Guzerat	34	— 5
	Kurrachee	89	+33
	Jacobabad	75	+17

The changes of humidity cannot be ascribed to temperature conditions, as temperature had increased considerably in the region of increasing, as well as in that of decreasing humidity.

Skies had clouded over rapidly in the Punjab and were overcast over nearly the whole of that area and in part of Upper Sind and at Quetta and Murree. They were clear in Lower Sind, Rajputana and Guzerat. Light showers had fallen at Quetta and Peshawar.

16th February.—During the previous 24 hours pressure had given way in North-Western India except Sind, and had increased in Southern and North-Eastern India. The fall exceeded a tenth of an inch in Rajputana, and a fairly well marked depression and cyclonic circulation lay between Jeypore and Deesa, in which pressure was nearly a tenth of an inch below the normal.

The following table gives data :—

STATION.	PRESSURE.			WIND.	
	8 A. M. reduced to sea- level and gravity at Lat. 45° .	Change in past 24 hours.	Variation from normal.	Direction, 8 A. M.	Mean velocity of previous 24 hours.
Ajmere	29.940	—'157	—'067	S-E	Miles. 6
Deesa	29.935	—'032	—'051	N-W	10
Neemuch	29.958	—'124	—'027	S-E	6

Winds were very light in Bengal and the North-Western Provinces, and many stations registered calms. They generally blew from the normal cold-weather directions, and were hence independent of the disturbance.

*Temperature had increased over the whole of Central and Northern India (except Sind and the West Punjab). The increase was most marked in front of the advancing depression, or in Rajputana, Guzerat and Central India. The mean temperature of the preceding 24 hours was upwards of 11° above the normal at Sambhar, Ajmere and Neemuch. The following gives the average variations of the temperature from the normal of the day:—

PROVINCE.	Variation of maximum of 24 hours preceding 8 A.M. of 10th.	² Variation of minimum of 24 hours preceding 8 A.M. of 10th.	Variation of mean of 24 hours preceding 8 A.M. of the 10th.
Punjab	$+0.6$	$+8.0$	$+4.3$
Sind and Rajputana	$+3.0$	$+6.0$	$+4.5$
Central India	$+7.2$	$+9.2$	$+8.2$
North-Western Provinces	$+4.8$	$+4.5$	$+4.7$
Central Provinces	$+5.5$	$+8.0$	$+6.8$
Bengal	$+3.0$	$+1.5$	$+2.3$
Burma	$+2.0$	$+4.1$	$+3.1$

The air was much damper in Guzerat, West Rajputana and (to a less extent) the Punjab. It was drier in the North-Western Provinces, East Rajputana and Bengal. The following gives mean humidity data of the storm area and the districts to which it was advancing:—

PROVINCE.	HUMIDITY.	
	Average at 8 A.M.	Change in past 24 hours.
Punjab	$\frac{\%}{82}$	$\frac{\%}{+4}$
West Rajputana	44	$+26$
Guzerat	63	$+29$
East Rajputana	55	-3
North-Western Provinces	74	-7

Skies were overcast over the whole of the Punjab, the western districts of the North-Western Provinces and the Western Himalayas, and were thickly clouded in Rajputana and lightly clouded in Central India. They were clearing at Quetta and in Upper Sind.

Rain had fallen generally in the North and West Punjab, and a few light showers in other districts (*i.e.* Sind, Rajputana, and the North-Western Provinces).

17th February.—During the preceding 24 hours the barometer had risen in North-Western India and fallen elsewhere. The fall exceeded $.05$ in an area including the greater part of the North-Western Provinces, Central Provinces, Bihar and West Bengal, and was greatest in a narrow belt extending from Meerut to Nagpur. Pressure was above

the normal over the greater part of India, the excess being greatest at Sibsagar ('08"), Bombay ('08") and Peshawar ('08"). A long narrow belt or trough of deficient pressure stretched from Ludhiana and Roorkee to Amraoti, Nagpur and Raipur, which was the continuation of the area of disturbance of the previous day.

The following table gives barometric and wind data of this area for 8 A.M. :—

STATION.	PRESSURE.			WIND.	
	8 A.M. reduced to sea-level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity preceding 24 hours.
Ludhiana	29'994	+ '041	— '005	Calm	5
Sirsa	29'981	+ '026	— '023	N-E	9
Roorkee	30'009	— '043	+ '014	Calm	4
Agra	29'983	— '017	— '026	Calm	9
Jeypore	29'978	+ '022	— '077	N-W	6
Jhansi	29'947	— '069	— '047	Calm	7
Hoshangabad	29'977	— '031	— '039	Calm	3
Saugor	29'957	— '057	— '064	SS-E	12
Jubbulpore	29'992	— '045	— '025	S-E	11
Nagpur	29'965	— '075	— '007	NN-E	8
Raipur	29'942	— '094	— '028	NN-E	4

The data show that the largest fall and the greatest negative variations from the normal were in the area represented by the stations of Nagpur, Jhansi and Saugor. The air circulation was very irregular, in no part of the trough showing a clearly defined cyclonic circulation, whilst immediately to the east at Lucknow, Benares and Raipur northerly winds prevailed.

Temperature had decreased rapidly in the Punjab, Sind, Rajputana, Central India, the Central Provinces and the western districts of the North-Western Provinces, in all of which rain had fallen. On the other hand, it had increased to a slight extent in the eastern districts of the North-Western Provinces and in Bihar. The following gives temperature data for the 24 hours preceding 8 A.M. :—

DISTRICT.	Variation from normal of maximum of 24 hours preceding 8 A.M., 17th.	Variation from normal of minimum of 24 hours preceding 8 A.M., 17th.	Variation from normal of mean of 24 hours preceding 8 A.M., 17th.	Change in previous 24 hours.
Punjab	—6'6	+8'9	+1'2	—4'1
Sind and Rajputana	—0'8	+2'3	+0'8	—6'7
Central India	+3'0	+2'8	+2'9	—5'2
North-Western Provinces	—1'5	+7'3	+2'9	—1'1
Central Provinces	+5'0	+6'4	+5'7	—1'5
Bihar	+3'0	+3'9	+3'5	+1'6
Bengal	+3'9	+0'9	+2'4	—0'2
Burma	+2'6	+3'5	+3'1	+0'5

The greatest variations were at the following stations immediately to the south and south-east of the depression, for which data are given below:—

STATION.	Variation from normal of maximum of 24 hours preceding 8 A.M., 17th.	Variation from normal of minimum of 24 hours preceding 8 A.M., 17th.	Variation from normal of mean of 24 hours preceding 8 A.M., 17th.
	°	°	°
Allahabad	+7.1	+9.1	+8.1
Jubbulpore	+6.7	+9.8	+8.3
Hoshangabad	+8.6	+7.4	+8.0
Akola	+5.0	+11.6	+8.3

A very considerable increase of humidity had occurred over the area in which rain had fallen. The air was generally drier in Bombay, Madras and Burma.

The following table gives the change in the humidity during the 24 hours:—

DISTRICT.	MEAN HUMIDITY.		Mean change during 24 hours.
	8 A.M., 17th.	8 A.M., 16th.	
South-East Punjab	% 95	% 66	% +29
North-Western Provinces	92	74	+18
Central India	83	45	+38
Central Provinces	70	42	+28
Rajputana	85	55	+30

This very large increase of humidity was almost entirely due to rainfall.

Skies were overcast over nearly the whole of the Punjab, the North-Western Provinces and Bihar, and in some parts of Rajputana, Central India and the Central Provinces, but were clearing in North-Western India.

The disturbance gave rain during the previous day to the greater part of the Punjab, the North-Western Provinces, Rajputana, Upper Sind, Central India and the greater part of the Central Provinces. Elongated depressions, such as the one under discussion, generally give hail storms over the southern portion of the trough, and the present was no exception. The four stations, out of the five in the Central Provinces which reported rain, had hail storms during the day.

18th February.—Pressure increased in Upper and Central India, and decreased in Burma, Bengal, the Deccan and Southern India. The rise exceeded .05 inch in Rajputana and the western districts of the North-Western Provinces, and the fall was slightly greater than .05 inch in North Bengal and Bihar. Neither the actual distribution of pressure nor the variations from the normal enable the position of the centre of the disturbance to be accurately determined. It was probably near Dehree in Bihar.

Skies had cleared during the previous 24 hours in the Central Provinces, Central India, Rajputana and the greater part of the Punjab. They were more or less clouded in the North-Western Provinces and Bihar, and were beginning to cloud over in Bengal.

The disturbance had hence filled up to a large extent and had advanced eastwards into the eastern districts of the North-Western Provinces and Bihar.

A large increase of humidity had occurred in Bihar and Chota Nagpur, ranging from 20. to 40, due chiefly to rainfall. Humidity had decreased slightly in Bengal, and to a moderate extent in the Punjab, Rajputana, Central India, and the Central Provinces.

Rain had fallen over the whole of Bihar, Chota Nagpur, the North-Western Provinces and the south-east districts of the Punjab. It had hence occurred almost entirely to the north, north-east and east of the advancing disturbance.

The continued rainfall of the previous 24 hours caused a further considerable reduction of temperature in Rajputana, Central India, the Central Provinces and the North-Western Provinces. Temperature had increased in Bengal and Burma in front of the advancing disturbance, more especially in the area represented by Purnea, Dhubri and Silchar, where the mean temperature of the previous 24 hours was $61\frac{1}{2}^{\circ}$ above the average.

The following table gives temperature data of the 24 hours preceding 8 A.M. for Northern and Central India:—

DISTRICT.	Variation from normal of maximum of 24 hours preceding 8 A.M., 10th.	Variation from normal of minimum of 24 hours preceding 8 A.M., 10th.	Variation from normal of mean of 24 hours preceding 8 A.M., 10th.
Punjab	0 -3.3	0 +4.8	0 +0.8
Sind and Rajputana	-6.5	+0.4	-3.1
Central India	-5.7	+1.1	-2.3
North-Western Provinces	-13.0	+4.8	-4.1
Central Provinces	-3.7	-0.7	-2.2
Bengal	+4.2	+3.1	+3.7
Bombay	-0.7	-1.0	-0.9
Madras	-0.4	-1.1	-0.8
Burma	+2.2	+4.4	+3.3

Winds were very light and irregular at this time over the whole of Northern and Central India. Six stations out of nine in the Punjab had calms at 8 A.M., and five out of nine in the North-Western Provinces. There was a slight tendency to the establishment of a cyclonic circulation in North Bihar and Bengal, but it did not influence the winds in South Bengal, which blew steadily from north to north-west. There was hence no indraught in the lower atmospheric strata to the disturbance from the adjacent sea area.

19th February.—The barometer fell over the whole of India, reducing pressure below the normal generally. The fall was brisk in South Bengal and the north-west of the Bay, and a very shallow depression covered this area, which was the continuation of the disturbance of the previous three days. Skies had partially cleared in the North-Western Provinces and Bihar, but were now overcast over nearly the whole of Bengal, and were clouding over in Upper Burma and Assam.

Winds were very light and irregular in Burma, Northern and Central India, and there

was no indication of a regular cyclonic circulation over the area of slight depression and disturbance. Thus, three out of four stations in East Bengal reported calms at 8 A.M., two out of three stations in Upper Burma, two out of five stations in Bihar, four out of nine stations in the North-Western Provinces, and four out of nine in the Punjab.

Light to moderate local showers had fallen in West and Central Bengal, and in Assam. A considerable increase of humidity (averaging 11) had taken place in the rainfall area, but to the east of it, in East Bengal and Upper Burma, humidity had decreased by amounts ranging from 2 at Bhamo to 15 at Burrisal.

The air was generally drier in Upper and Central India.

A brisk fall of the barometer had occurred in Upper India and the adjacent Himalayan area, due to a very slight disturbance which had given some snow showers to the hill districts.

The temperature of the preceding 24 hours was considerably in excess in North Eastern India, and the area of greatest excess was transferred to East Assam, East Bengal and Burma. The excess was actually greatest at Sibsagar (7°8'), Dacca (5°2'), and Silchar and Thayetmyo (5°1').

Temperature was increasing very rapidly on the north-west frontier, and the temperature conditions were approximating to those which usually prevail before the appearance of a depression in North-West India. The mean temperature of the previous 24 hours was upwards of 4° above the normal at Quetta (+7°4'), Hyderabad (+5°5'), and Kurrachee (+4°5'). Between these two areas of excessive temperature was an area in which temperature was more or less below the average. The deficiency was greatest in a narrow area stretching from Jeypore to Malegaon and Khandwa, in which it averaged 4°.

The following table gives average temperature variation data for the 24 hours preceding 8 A.M. of the 19th:—

DISTRICT.	Variation from normal of maximum of 24 hours preceding 8 A.M., 19th.	Variation from normal of minimum of 24 hours preceding 8 A.M., 19th.	Variation from normal of mean of 24 hours preceding 8 A.M., 19th.
Punjab	0	0	0
Sind and Rajputana	-0°6	+5°6	+2°5
Central India	-2°6	+2°4	-0°1
North-Western Provinces	-3°9	+0°4	-1°8
Central Provinces	-6°3	+4°1	-1°1
Bombay	-5°3	-0°6	-3°0
Bombay	-1°7	-2°7	-2°2
Madras	0	+0°3	+0°2
Bengal	+1°6	+4°8	+3°2
Burma	+1°7	+5°3	+3°5

20th February.—The most important barometric changes were now taking place on the North-West frontier, where a depression was forming. The history of this storm is given separately. We proceed to trace the progress of the depression and disturbance under discussion.

The barometer had fallen in North-Eastern India during the preceding 24 hours. The fall slightly exceeded .05 inch in East Bengal. The barometer rose in the North-West

Provinces, Bihar and Central India. The disturbance was hence now transferred to East Bengal and Cachar. The following gives barometric and wind data of this area :—

STATION.	BAROMETER.			WIND.	
	8 A.M. reduced to sea- level and gravity at Lat. 45°.	Change in past 24 hours.	Variation from normal.	Direction.	Mean velocity previous 24 hours.
Silchar	29°905	—°071	—°086	Calm	2
Dacca	29°873	—°056	—°102	S.S.-E.	3
Burrisal	29°876	—°048	?	Calm	2
Chittagong	29°904	—°055	—°078	Calm	2

The depression was hence deeper and the disturbance greater than on the previous day. The chief feature of the air motion was the stillness of the atmosphere over the depression and also to the east in Upper Burma, where two out of the three recording stations reported calms. Winds were north-east at Akyab and Saugor Island, and were hence apparently unaffected by the depression in East Bengal. Light north-east winds prevailed over the whole of the Bay (as is established by the logs of vessels in the Bay.)

The air was much damper in Bengal and Bihar, where fairly general and moderately heavy rain had fallen. Skies had cleared in the North-Western Provinces, Chota Nagpur, South Bihar and South-West Bengal. They were overcast in East Bengal and Assam, and were rapidly clouding over in Upper Burma. Rain had fallen over the greater part of Orissa, Bengal, West Assam and North Bihar, but the largest amounts were recorded in East Bengal.

Temperature had fallen rapidly during the previous 24 hours in the rainfall area. It was in excess in Assam and Burma, the greatest positive variations during the previous 24 hours being Thayetmyo (+6°4'), Toungthoo (+5°0'), and Sibsagar (+4°9'). The area of increasing and excessive temperature in North-Western India had advanced eastwards as far as the meridian of 70°E., and the greatest excess of temperature was now in the Indus Valley at Hyderabad (9°0') Jacobabad (7°8'), Dera Ismail Khan (6°4'), and Peshawar (6°3'). The mean temperature for the same interval at Quetta was only 3°4' above the normal.

The following table gives temperature data for the preceding 24 hours in the same form as hitherto :—

AREA.	Variation from normal of maximum of 24 hours preceding 8 A.M. of 20th.	Variation from normal of minimum of 24 hours preceding 8 A.M. of 20th.	Variation from normal of mean of 24 hours preceding 8 A.M. of 20th.
Punjab	+0°7	+5°7	+3°2
Sind and Rajputana	+2°7	+4°3	+3°5
Central India	—1°8	—0°4	—1°1
North-Western Provinces	—5°0	+1°5	—1°8
Central Provinces	—4°5	—4°1	—4°3
Bombay	—0°6	—2°2	—1°4
Madras	+0°4	+0°2	+0°3
Bengal	—2°7	+2°6	—0°1
Burma	+2°4	+6°0	+4°2

21st February.—Pressure had increased briskly ('05" to '10") in Bengal, and was unchanged in Burma. A shallow depression in which the barometer was about '05" below the normal lay over Burma. The depression was probably greatest in Central and Upper Burma, but the normals for that area are wanting. Skies had cleared over the whole of Bengal, but were overcast in Assam and part of Upper Burma. They were free from cloud in Lower Burma. Light showers had been received in Assam and at a few stations in East Bengal and Upper Burma.

The disturbance was hence now filling up and was very feeble. It apparently either passed eastwards or filled up during the next 24 hours, as skies were clear in Upper Burma on the morning of the 22nd. No rain fell in Assam or Upper Burma during the preceding 24 hours. The following table gives the temperature data of the 21st and 22nd, as they are very interesting as showing the eastward march of the depression of temperature which accompanied and followed the disturbance :—

DISTRICT	21ST FEBRUARY.			22ND FEBRUARY.		
	Variation from normal of maximum of 24 hours preceding 3 A.M. of date.	Variation from normal of minimum of 24 hours preceding 3 A.M. of date.	Variation from normal of mean of 24 hours preceding 3 A.M. of date.	Variation from normal of maximum of 24 hours preceding 3 A.M. of date.	Variation from normal of minimum of 24 hours preceding 3 A.M. of date.	Variation from normal of mean of 24 hours preceding 3 A.M. of date.
Punjab	+1'4	+6'0	+3'7	-0'6	+7'7	+3'6
Sind and Rajputana . . .	+3'8	+5'9	+4'9	+5'3	+9'3	+7'3
Central India	-0'8	+1'2	-0'2	+1'9	+2'8	+2'4
North-Western Provinces .	-4'8	+2'5	-1'2	-0'1	+4'0	+2'0
Central Provinces	-5'2	-3'5	-4'4	-0'5	-0'6	-0'6
Bengal	-5'2	-0'4	-2'8	-5'7	-0'9	-3'3
Burma	+1'3	+4'4	+2'9	-0'9	+0'6	-0'2

The following gives a summary of the more important features of the disturbance :—

1st.—It is not possible to fix accurately the positions of the centre of the disturbance.

It undoubtedly marched in an easterly direction from Sind across Northern India into Burma and probably broke up in Burma. A central line through the area of disturbance running approximately north and south, was probably in about Long. 67° on the 15th, Long. 73° on the 16th, Long. 78° on the 17th, Long. 83° or 84° on the 18th, Long. 88° on the 19th, Long. 91° on the 20th, and about Long 95° or 96° on the 21st, but its position on that day is very doubtful, as it had almost filled up, and the indications of its existence are so slight as to make it very probable that the disturbance had almost disappeared. Its rate of motion was hence about 400 miles *per diem* when entering India and about 200 miles *per diem* when passing into Burma. Its average rate of motion during the six days it took to cross India was hence approximately 300 miles *per diem*.

2nd.—It gave a general burst of rain to the whole of Northern and Central India. The following gives a brief summary of the distribution of rain during the storm :—

DISTRICT.	RAINFALL OF 24 HOURS PRECEDING 6 P.M. OF THE							Total rainfall, 15th to 21st.
	15th.	16th.	17th.	18th.	19th.	20th.	21st.	
	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.	Inch.
Punjab	0'03	0'23	0'39	0'13	0'04	0'02	0'01	0'85
Sind	0'07	0'04	0	0	0	0	0	0'11
Rajputana	0	0'03	0'03	0'01	0	0	0	0'07
North-Western Provinces	0	0'06	0'74	0'29	0'20	0'04	0	1'33
Oudh	0	0	0'56	0'09	0'21	0'05	0	0'91
Central India	0'07	0'14	0'37	0'03	0'07	0	0	0'68
Central Provinces and Berar	0'01	0'06	0'11	0	0	0	0	0'18
Bengal	0	0	0'05	0'09	0'24	0'28	0'01	0'67
Assam	0	0	0	0'01	0'05	0'19	0'20	0'45
Burma	0	0	0	0	0	0	0	Nil

3rd.—A noteworthy feature of the air motion in the area of disturbance was the absence of any well-defined cyclonic circulation. The winds were throughout light and variable, and the majority of the stations in the central area reported calms. This feature was as conspicuous when the depression was passing through Burma and Bengal as when it was on the North-West frontier. Another important feature of the air motion was that during the whole of its existence north to north-east winds prevailed on the west coast south of Kurrachee and northerly winds at the head of the Bay of Bengal. There was hence no general indraught from the adjacent sea areas in the lower atmospheric strata which would account for the rainfall of the storm.

4th.—The cloud and rainfall occurred chiefly in the northern half of the area of disturbance and in the hill districts to the north, whilst over the southern half of the area of disturbance skies were clear during the greater part of its existence.

5th.—One of the most noteworthy features of the storm was the striking temperature conditions which accompanied it. In front of the storm, temperature was, during the whole of its existence, very largely in excess, and the area or belt of high temperature conditions advanced in front of the storm at the same rate as the storm itself. The following gives the

position of the greatest excess of temperature and its amount from day to day during the period 15th to 21st :—

DATE.	Position of the greatest excess of temperature.	Amount of excess of mean temperature of 24 hours preceding 8 A.M. of date.
15th	Peshawar	+ 11'7
	Mooltan	+ 10'4
	Jacobabad	+ 9'8
16th	Ajmere	+ 11'4
	Neemuch	+ 11'3
	Khandwa	+ 10'9
17th	Akola	+ 8'3
	Hoshangabad	+ 8'0
	Jubbulpore	+ 8'3
	Allahabad	+ 8'1
18th	Purneah	+ 6'3
	Dhubri	+ 6'6
	Silchar	+ 6'5
19th	Sibsagar	+ 7'8
	Purnea	+ 6'7
20th	Sibsagar	+ 4'9
	Thayetmyo	+ 6'4
21st	Thayetmyo	+ 4'0

In the storm area itself temperature was largely reduced by the rainfall, and this effect, together with the effect due to the setting in of cool north-westerly winds in the rear of the storm, gave rise to a very broad belt of diminished temperature following the narrower belt of excessive temperature in its front and which advanced eastwards at the same rate approximately as the disturbance.

The line of greatest depression of temperature was at some distance in the rear of the storm. The following data give its approximate position from day to day :—

DATE.	Stations at which the depression of temperature was greatest on date.	Amount of depression of mean temperature of 24 hours preceding 8 A.M. of date.
18th	Ajmere	- 8'2
	Jeypore	- 6'0
	Delhi	- 7'7
19th	Jeypore	- 4'4
	Khandwa	- 5'0
	Amraoti	- 7'0

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DATE.	Station at which the depression of temperature was greatest in dates.	Amount of depression of mean temperature of 24 hours preceding 8 A.M. of date.
20th	Nagpur	-5'3
	Seoni	-5'1
	Sholapur	-5'5
21st	Seoni	-6'9
	Hazaribagh	-6'5
22nd	Gaya	-5'4
	Berhampore	-5'2
	Calcutta	-6'9
	Saugor Island	-5'4
23rd	Vizagapatam	-4'4
	Calcutta	-3'2
	Toungoo	-3'3

6th.—Another important point was the decrease of humidity and also of the amount of aqueous vapour present in the atmosphere in front of the cyclone and the very rapid increase of this element in the rainfall area of the disturbance concurrently with rainfall and the gradual and slow decrease in the rear of the disturbance. It is a very strong proof of the absence of any sea winds from the Bay of Bengal feeding into the area of disturbance whilst it was crossing Central India, Chota Nagpur, South Bihar, and part of Bengal. As this is a most important point it appears to be desirable to give a summary of the evidence scattered through the discussion :—

STATION.	CHANGE OF AQUEOUS VAPOUR PRESSURE DURING 24 HOURS PRECEDING 8 A.M. OF THE				
	16th.	17th.	18th.	19th.	20th.
Deesa	+127	+066	-026	-063	-005
Sutna	-049	+257	-017	+036	-080
Allahabad	-073	+174	-058	+058	-078
Hazaribagh	-023	+002	+140	-003	-063
Burdwan	-021	-019	+082	+105	-039
Dacca	-013	+026	+036	+019	+005

Depression of February 20th to 25th.—This was one of the more remarkable of the cold-weather storms of recent years. It was during the latter part of its existence a well-defined cyclonic storm. It advanced in a northerly direction, and hence not along the easterly track followed by the great majority of cold-weather storms. It gave an unusually heavy burst of rain to the North Punjab.

Pressure was increasing on the 17th over the whole of North-Western India and was above the normal by small amounts on the morning of the 18th. The excess was greatest in Sind and at the foot of the Western Himalayas, where it ranged from '05" to '07". It was absolutely greatest at Quetta ('11").

Temperature was considerably above the normal in Baluchistan and the North Punjab. The excess was greatest at Quetta (5°) and at Sialkot (4°), but did not exceed 2° in the Indus Valley.

Skies were clear over the whole of North-Western India. Very light winds and calms prevailed in the Punjab and Sind.

19th February.—The barometer fell briskly during the preceding 24 hours in North-Western India. Pressure was very uniform in that area and was reduced slightly below the average. The fall at Quetta was very small and pressure was '09" above the normal at that station.

Temperature had increased considerably in Baluchistan, Sind, and the Punjab. The excess was greatest at Quetta (7°), Hyderabad (5°) and Kurrachee (4°).

The air was generally somewhat drier in North-Western India.

Skies were clear over the Punjab plains, Sind, Rajputana and Central India, and very slightly clouded at Quetta.

20th February.—The barometer continued to fall on the 19th in North-Western India, and on the morning of the 20th a fairly well-marked depression was in existence in Sind. The following gives the barometric and wind data of stations in the area of depression:—

STATION.	PRESSURE REDUCED TO SEA-LEVEL AND CONSTANT GRAVITY.			WIND.	
	8 A.M.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.
Quetta	...	—'070,	+ '012	N	3
Mooltan	29'987	—'001	—'056	SE	1
Jacobabad	29'938	—'043	—'097	Calm	3
Hyderabad	29'919	—'033	—'113	SW	7
Kurrachee	29'946	—'019	—'082	WSW	15

The wind had shifted at Quetta from north north-west at 8 A.M. of the 19th to north at the same hour of the 20th and skies had cleared again at that station. They were now partially clouded in Sind.

The data hence show that there was a very shallow depression in existence in Sind. The Quetta observations establish that it had not passed through North Baluchistan. The wind observations at Kurrachee on the 19th and 20th also indicate that the depression did not enter Sind from South Baluchistan or the Arabian Sea. The shallow depression in Sind was hence probably the product of the changes in progress in North-Western India during the previous 48 hours, the most important being the slow and steady decrease of pressure, and which it may fairly be assumed was due to ascensional movement in the middle or higher atmospheric strata, as it had already given rise to the formation of cloud in Sind.

Temperature had further increased in North-Western India, and the area of excess temperature now included Kathiawar and West Rajputana in addition to Baluchistan, Sind, and the Punjab.

The excessive temperature was now very marked at the Indus Valley stations as is shown by the following data :—

STATION OR DISTRICT.	Variation of maximum temperature.	Variation of minimum.	Variation of mean.
	°	°	°
Hyderabad	+9'4	+8'5	+9'0
Jacobabad	+7'2	+8'4	+7'8
Dera Ismail Khan	+0'4	+12'4	+6'4
Peshawar	+3'1	+9'4	+6'3
Sind	+5'7	+9'0	+7'4
Punjab	+0'3	+5'4	+2'9

The data show that the increased temperature was chiefly due to the night temperatures being abnormally high. This was due to a veil of cloud having extended over the whole of the Punjab. Skies were clear at Quetta and over the whole of Central India and the Gangetic Plain, and also at the hill stations from Simla eastwards. Humidity had decreased rapidly at the hill stations. The following data show that it was not due to increasing temperature :—

STATION.	Change of temperature in 24 hours preceding 8 A.M. of 20th.	Change of aqueous vapour.	Change of humidity.
	°	"	%
Quetta	-3'0	+ '023	+1
Ranikhet	-3'5	- '012	-16
Mussooree	+3'7 ?	- '008	-13
Simla	-1'5	- '015	-11
Murree	+1'3	- '024	-12
Mount Abu	+3'8	+ '042	-1

Light northerly winds prevailed at Quetta and Murree and light irregular and unsteady winds in the Punjab and North-Western Provinces.

The whole of the observations are hence in favour of the assumption that a depression was forming on the 19th and 20th in Sind, due to local actions and conditions, and that it was not due to the eastward advance of a disturbance from Baluchistan or to the northward advance of a depression from the north of the Arabian Sea.

21st February.—The barometer had fallen in North-Western India during the preceding 24 hours. The fall was greatest in Upper Sind and the South-West Punjab, where it slightly exceeded '05".

The depression now covered Upper Sind and the South-West Punjab, so that it had apparently moved a little to the north during the past 24 hours. The following gives barometric and wind data of the area of depression:—

STATION.	PRESSURE REDUCED TO SEA-LEVEL AND CONSTANT GRAVITY.			WIND.	
	8 A.M.	Change in past 24 hours.	Variation from normal.	Direction.	Average hourly velocity previous 24 hours.
Quetta	...	—'041	—'032	SE	4
Kurrachee	29'944	—'002	—'081	WSW	15
Hyderabad	29'906	—'013	—'024	SW	11
Jacobabad	29'878	—'060	—'155	NE	2
Mooltan	29'932	—'055	—'118	SE F	1

The preceding data show that a fairly well-marked cyclonic circulation, the centre of which was a little to the east-south-east of Jacobabad, was established, and that strongish winds were blowing across the Sind Coast into the depression. Light northerly winds prevailed in East Rajputana and westerly winds in the North-Western Provinces, and were hence not dependent upon the depression.

Temperature had further increased in North-Western India, and the area of excess temperature now included Rajputana and the western districts of Central India. The greatest excess of temperature was again shown at the Indus Valley stations and at Quetta. The following give data:—

STATION OR DISTRICT.	Variation of maximum.	Variation of minimum.	Variation of mean.	Change during previous 24 hours.
Quetta	+14'9	+13'3	+14'1	+11'6
Hyderabad	+7'3	+10'3	+8'8	0
Jacobabad	+7'5	+7'2	+7'4	+0'2
Dera Ismail Khan	+0'8	+11'5	+6'2	+0'5
Peshawar	+0'5	+13'4	+7'0	+1'5
Punjab	+1'4	+6'0	+3'7	+1'2
Sind and Rajputana	+3'8	+5'9	+4'9	+1'9
Kathiawar and Central India	+0'8	+1'2	+1'0	+1'9

The preceding data show that in Sind and North Baluchistan the elevation of temperature was as marked in the day as well as the night temperature, whilst in the Punjab it was almost entirely in the night temperature and due to the presence of cloud.

Humidity had decreased very rapidly at the hill stations of Simla, Mussoorie and

Ranikhet, and had also diminished over the whole of India with a few exceptions. The following gives data showing the character of the change at the hill stations:—

STATION.	Change of temperature.	Change of humidity.	Change of aqueous vapour pressure.
	°	%	"
Ranikhet	+8°0	—43	—°064
Mussoorie	+0°8	—47	—°069
Simla	+7°7	—36	—°040

Skies were overcast in the North Punjab and more or less clouded in Sind, Rajputana and Central India.

With the exception of very light showers at Murree and Rawalpindi no rain had fallen during the previous 24 hours.

Hence the depression had increased slightly in intensity and extended slightly northwards. The cloud area had also extended eastwards and the thickness of cloud was probably greatest in the North Punjab, where a few very light showers had been received. The disturbance was hence as yet very feeble.

February 22nd.—During the preceding 24 hours the barometer fell over nearly the whole of India, briskly in North-Western and Central India and slightly elsewhere. As the amount of the fall was very nearly uniform over North-Western India, the relative distribution of pressure was unaltered. The depression overlay Sind and the south-west districts of the Punjab, but the amount of depression now exceeded two-tenths of an inch. The following gives wind and barometric data for the area:—

STATION.	PRESSURE REDUCED TO SEA-LEVEL AND CONSTANT GRAVITY.			WIND.		Cloud, 8 A.M.	Rain previous 24 hours.
	8 A.M.	Change in past 24 hours.	Variation from mean.	Direction, 8 A.M.	Mean velocity previous 24 hours.		
Quetta	...	—°054	—°087	W	4	4	...
Kurrachee	29°866	—°078	—°153	WSW	18	8	...
Hyderabad	29°825	—°081	—°200	SW	12	3	...
Jacobabad	29°811	—°067	—°215	SE	3	6	...
Mooltan	29°866	—°066	—°175	NW	1	8	...

Northerly winds prevailed at 8 A.M. in the Punjab and westerly winds in Rajputana, hence the cyclonic circulation in the area of depression had not yet extended beyond Sind. Similarly the wind at Quetta was in no way related to the cyclonic circulation. The centre of the depression, so far as it can be inferred from the wind directions, was to the west-south-west of Jacobabad, and hence the depression had apparently moved southwards and returned to the position it occupied on the 20th. It is, however, probably more correct to assume that the disturbance was a very feeble one as yet, and that the cyclonic circulation in the lower atmosphere was in an initial stage and very imperfectly developed, and hence that it is misleading to follow the apparent centre of such an area in the same way as it is usual to track the centre of a cyclonic storm. Hence, all that can be fairly concluded is that the depression occupied practically the same area as during the pre-

vious two days, and that it had intensified very slowly and was still a very feeble disturbance.

The area of excess temperature had again extended eastwards and now included the whole of the North-Western Provinces and Central India in addition to Rajputana, the Punjab, Sind and Baluchistan. The following data show the character of the temperature variations from the normal at this time:—

STATION OR DISTRICT.	Variation of maximum from normal.	Variation of minimum from normal.	Variation of mean from normal.	Change since previous day.
Quetta	+16·8	+14·0	+15·4	+2·2
Jacobabad	+7·9	+11·2	+9·6	+2·3
Ajmere	+6·8	+12·5	+9·7	+7·4
Hyderabad	+6·4	+11·9	+9·2	+1·0
Dera Ismail Khan	+1·2	+13·9	+7·6	+2·0
Sind and Rajputana	+5·3	+9·3	+7·3	+2·6
Punjab	—0·6	+7·7	+3·6	+0·5
Central India	+1·9	+2·8	+2·4	+2·8
North-Western Provinces	—0·1	+4·0	+2·0	+4·0

The preceding data show that in the central area of depression in Sind and West Rajputana the day temperature was nearly as excessive as the night temperature, whereas outside the depression in the Punjab and North-Western Provinces the excess was chiefly, if not entirely, due to the high night temperature.

The changes of humidity were not large, except at the hill stations, where a rapid increase (accompanying a large increase of temperature) had occurred and was hence not due to temperature variations. The variations in other districts were mainly due to changes of temperature as is shown by the following most striking cases:—

DISTRICT.	Change of temperature.	Change of humidity.	Change of aqueous vapour pressure.
Central India	+4·8	—17	—·033
Rajputana	+2·7	—5	—·008

Skies were now overcast at the hill stations (except Quetta) and over the greater part of the Punjab. The extent of cloud had increased very considerably and skies were now more or less clouded in the North-Western Provinces, the Central Provinces, Berar, Central India, Rajputana and Sind.

Over the greater part of the cloud area no rain had fallen. Light showers had been received at Simla, Murree, Peshawar and Rawalpindi, or considerably to the north of the depression.

February 23rd.—The barometer had risen over the whole of India except North-Western and Central India. The changes were every where small except in the West and South-West Punjab, where they slightly exceeded ·05". The depression had hence

developed further and now covered the South-West Punjab and Upper Sind. There was a well-marked cyclonic circulation in existence in North-Western India, the centre of which was between Jacobabad and Mooltan at 8 A.M. The following gives barometric and wind data of this area for 8 A.M.:—

STATION.	PRESSURE REDUCED TO SEA-LEVEL OR CONSTANT GRAVITY.			WIND.		Cloud, 8 A.M.	Rain previous 24 hours.
	8 A.M.	Change in past 24 hours.	Variation from normal.	Direction. 8 A.M.	Mean velocity previous 24 hours		
	"	"	"				Inches.
Dera Ismail Khan	29.838	—'058	—'205	NNE	2	8	0.19
Quetta	...	—'008	—'098	NNE	4	10	1.01
Jacobabad	29.790	—'021	—'230	Calm	5	3	...
Mooltan	29.788	—'078	—'238	NW	2	10	...
Kurrachee	29.852	—'014	—'160	WSW	20	4	...
Hyderabad	29.838	+ '013	—'177	SW	20	3	...
Deesa	29.910	—'006	—'082	S	10	7	...
Sirsa	29.839	+ '001	—'167	SE	6	9	...
Lahore	29.862	—'006	—'149	E	4	10	0.60

There was now a well-marked depression and cyclonic circulation which extended over the whole of North-Western India. Strong south-west winds prevailed in Lower Sind and also at Mount Abu, and strong south-east winds (average velocity 18 miles an hour) at Murree. Over the greater part of the area the winds were somewhat above the normal, but were feeble. The average air movement in the Punjab during the previous 24 hours was only 3 miles per hour and in Rajputana 5 miles.

Temperature had fallen considerably in the north of the Punjab in consequence of rainfall and was slightly below the normal at Peshawar and Murree. The area of excessive temperature continued to extend eastwards, and now included Bihar and the greater part of the Central Provinces. The following gives temperature variation data for the previous 24 hours:—

DISTRICT.	Variation of maximum from normal.	Variation of minimum from normal.	Variation of mean from normal.	Change in previous 24 hours.
	°	°	°	°
Punjab	—3.2	+8.1	+2.5	—1.1
Sind and Rajputana	+2.3	+9.6	+6.0	—1.3
North-West Provinces	+1.2	+7.1	+4.2	+2.2
Central India	+3.7	+3.1	+3.4	+1.0
Central Provinces	+1.7	—0.4	+0.7	+1.3
Bengal	—3.4	+1.2	—1.1	+1.2

The area of greatest excess of temperature stretched from Quetta and Sind to Meerut, Lucknow and Allahabad. Over this area the mean temperature was upwards of 5° in excess. The excess was absolutely greatest at Hyderabad (7.9°) and Quetta (9.9°). The

air was generally damper in North-Western India, but it was only at the hill stations that the humidity had increased largely. The increase ranged from 9 at Mussoorie to 26 at Quetta. The air was now nearly saturated in Upper India, and more especially at the hill stations. Skies were overcast in the Punjab and western districts of the North-Western Provinces, and were more or less clouded over the whole of Northern and Central India, and also in Upper Burma and the North Deccan. It should be noted that skies were clear at Mooltan and lightly clouded (average amount 3) in Sind.

General rain had fallen over the whole of the Punjab, except in the south-west district of Mooltan, and the south-east districts of Delhi, Umballa, Hissar and Gurgaon, and also heavy rain or snow in the hill districts. The rainfall hence occurred at a considerable distance to the north and north-east of the depression, whilst none had fallen in the central depression area between Mooltan and Jacobabad. This is the more remarkable considering the strong southerly winds blowing across the Sind Coast.

February 24th.—Pressure had increased over the whole of India, except the Punjab, Rajputana and the North-Western Provinces. The changes were small, except in the Punjab, where the barometer had fallen, more especially at the north-western stations. These changes accompanied the northward march of the depression which now lay over the western districts of the Punjab between Peshawar and Mooltan, the centre of the depression being a little to the south of Dera Ismail Khan at 8 A.M. The amount of the depression at the centre now exceeded three-tenths and the disturbance was hence one of considerable intensity. The following table gives barometric and wind data at stations in the storm area :—

STATION.	PRESSURE REDUCED TO SEA-LEVEL AND CONSTANT GRAVITY.			WIND.			
	8 A.M.	Change in past 24 hours.	Variation from normal.	Direction.	Mean velocity previous 24 hours.	Cloud, 8 A.M.	Rain previous 24 hours.
	"	"	"	"	"	"	Inch.
Peshawar	29.730	—168	—298	SE	2	10	0.57
Dera Ismail Khan	29.719	—119	—318	SE	2	10	0.43
Mooltan	29.748	—040	—274	NNW	2	10	0.29
Rawalpindi	29.758	—103	—244	ENE	4	10	3.73
Lahore	29.764	—098	—239	Calm	10	10	2.43
Roorkee	29.856	—068	—115	SE	6	10	0.03
Sirsa	29.803	—036	—195	S	10	3	0.88
Jacobabad	29.834	+044	—179	WNW	4	0	0.09
Hyderabad	29.886?	+048	—122	W	15	5	...
Kurrachee	29.900	+048	—101	NW	20	7	...

The winds in Sind, the Punjab, Rajputana and the North-Western Provinces were dependent on the depression. In Central India three out of the four stations reported calms. The above wind data show conclusively that in the central depression the winds were very light, and that at distances of 300 to 600 miles from the centre strong winds were blowing.

Unusually strong winds prevailed at the hill stations. The following gives data:—

STATION.	Actual wind, Direction.	Mean hourly velocity.	Normal wind, Direction.	Normal mean hourly velocity, February.
Mount Abu	WSW	17	N 71° W	6
Murree	SE	23	S 39° E	8

When the positions of these stations are considered it is evident that the cyclonic circulation was much stronger at an elevation of 5,000 to 7,000 feet than at the earth's surface.

Temperature had fallen rapidly in the Punjab and North Sind in consequence mainly of the heavy rainfall of the previous 24 hours. The mean temperature of the previous 24 hours was 74° in defect at Quetta, 59° at Lahore, and 52° at Dera Ismail Khan.

The area of excess temperature had extended eastwards over the greater part of Bengal. The greatest excess of temperature was in a limited area immediately to the south-east of the depression and defined by the following stations, *viz.*, Sirsa, Bareilly, Lucknow and Ajmere. In this area the excess ranged from 6° to 8°.

The following table gives temperature variation data for the previous 24 hours:—

DISTRICT.	Variation of maxi- mum from normal.	Variation of mini- mum from normal.	Variation of mean from normal.	Change in previous 24 hours.
Punjab	-7.2	+5.7	-0.8	-3.3
Sind and Rajputana	+2.2	+7.1	+4.7	-1.3
North-West Provinces	-0.9	+10.1	+4.6	+0.4
Central India	+1.9	+6.0	+4.0	+0.6
Central Provinces	+3.4	+2.7	+3.1	+2.4
Bengal	-1.7	+1.2	-0.3	+0.8

The chief features indicated by the preceding data are first the unusually high night temperatures in the plains of Northern and Central India in consequence of the cloud canopy largely diminishing the resultant radiation at night; and, secondly, the decreased day temperature in the area of rainfall in the Punjab. In that area the day temperature was 7° in defect and the night temperature 6° in excess, thus giving a diminished range of temperature in the 24 hours amounting to 13°.

On the other hand, the day and night temperatures at the hill stations were reduced, and hence the variation of the mean temperature of the day from the normal was larger at the hill than the plain stations. The following gives data for typical stations in illustration of these remarks:—

STATION.	Variation of maxi- mum from normal.	Variation of mini- mum from normal.	Variation of mean from normal.
PLAIN STATIONS	0	0	0
{ Lahore	-17.6	+5.9	-5.9
{ Peshawar	-12.5	+8.8	-1.9
HILL STATIONS	0	0	0
{ Simla	-10.8	+4.2	-7.5
{ Murree	-9.7	-6.3	-8.0
{ Quetta	-12.5	-2.3	-7.4

The air was damper in the Punjab and drier in Rajputana and the North-Western Provinces, but the changes were due almost entirely to temperature changes, and not to alterations in the amount of aqueous vapour present in the air, except in the rainfall area.

Skies were overcast in the Punjab and western districts of the North-Western Provinces, and were more or less clouded over the whole of Northern and Central India.

As on the previous day, the rainfall of the preceding 24 hours was confined to the Punjab and the neighbouring hill districts, and was heaviest to the north and east of the centre. The precipitation of the previous 24 hours was abnormally heavy in the Punjab, and was the heaviest downpour received during the cold weather for many years (at least since 1878). The following table gives a statement of the rainfall at the more important stations of the Punjab:—

STATION.	Amount of rainfall during 24 hours preceding 6 P.M. of the 24th.
Abbottabad	4.10 inches.
Murree	5.02 „
Chamba	3.37 „
Dharmasala	1.80 „
Kailong	1.92 „
Kilba	2.16 „
Simla	1.69 „
Rawalpindi	3.73 „
Jhelum	1.50 „
Gujrat	1.00 „
Sialkot	2.33 „
Gujranwalla	1.40 „
Gurdaspur	1.80 „
Dhariwal	1.40 „
Lahore	2.43 „
Amritsar	2.30 „
Ferozepur	2.30 „
Jullundur	1.30 „
Hoshiarpur	1.10 „
Ludhiana	1.87 „
Umballa	3.30 „

25th February.—The deep depression which was in existence in the West Punjab on the morning of the 24th was then advancing northwards, rolling, as it were, along the eastern flank of the Suleiman and Afghan mountains. It was approaching the great knot of mountains to the north of the Peshawar, Rawalpindi and Hazara districts, behind which is the Pamir plateau, the highest tableland in the world, and the average elevation of which is about 18,000 feet. The depression was apparently unable to cross these

mountains, and the obstruction which they offered to the continuance of the cyclonic circulation in the northern and eastern quadrants was so great that it rapidly broke up on the evening of the 24th. In consequence of these actions pressure increased rapidly in North-Western India. The increase in the North Punjab was unusually large. It exceeded half an inch at Peshawar and four-tenths of an inch over the whole of the West Punjab. The depression hence not merely filled up, but was replaced by high pressure, the barometer being at 8 A.M. of the 25th nearly two-tenths of an inch above the normal in the North Punjab.

The following gives barometric 8 A.M. data of the 25th for representative stations in the Punjab, Sind and Rajputana:—

STATION.	PRESSURE.		
	8 A.M.	Change in past 24 hours.	Variation from normal.
Peshawar	30°240	+°510	+°189
Dera Ismail Khan	30°180	+°461	+°143
Sialkot	30°116	+°372	+°130
Lahore	30°144	+°380	+°149
Sirsa	30°107	+°304	+°114
Mooltan	30°130	+°382	+°117
Kurrachee	30°016	+°116	+°030
Ajmere	30°113	+°233	+°069
Agra	30°074	+°176	+°084
Murree	23°912	+°334	+°073
Simla	23°279	+°153	+°026
Quetta	24°788	+°172	+°132
Ranikhet	24°163	+°042	+°065
Mount Abu	26°154	+°133	+°039

This rapid rise of the barometer accompanied a rapid clearing of the skies, so that at 8 A.M. of the 25th skies were free from cloud over nearly the whole of North-Western India.

The following table gives mean cloud data of the 24th and 25th for comparison:—

DISTRICT.	Amount of cloud at 8 A.M. of 24th.	Amount of cloud at 8 A.M. of 25th.
Punjab	8·6	0·4
Hill Stations (Upper India)	10·0	0
Rajputana	8·0	0
Sind	4·0	0
North-West Provinces	7·8	2·6
Central India	7·5	3·0
Central Provinces	5·4	1·2

The preceding data establish that the clearing of the skies was most rapid and complete in the area of greatest rise of the barometer, an almost conclusive proof that it was almost solely due to a descending movement of the atmosphere which extended through a great elevation.

The preceding storm was one of the more remarkable cold weather storms of recent years. The following were a few of the more noteworthy features of the storm:—

1st.—The storm did not pass into the Indian area from Baluchistan or the Arabian Sea. It formed slowly in Sind on the 20th, 21st and 22nd, during which period it was practically stationary. The cyclonic circulation was somewhat irregular at this period. It became well marked with a definite centre of convergence, and began to move northwards on the afternoon of the 22nd. At the same time the cyclonic circulation gradually extended northwards and eastwards over the Punjab, Rajputana, Central India, and the greater part of the North-Western Provinces on the 23rd and 24th. The centre on the morning of the 22nd was near and to the north of Jacobabad, on the 23rd about midway between Jacobabad and Mooltan, and on the 24th, a little to the south of Dera Ismail Khan. The depression filled up during the next 24 hours. It travelled at an average rate of about 6·3 miles an hour from the morning of the 22nd to that of the 24th, and increased slowly in speed as it advanced northwards. Its track was a very unusual one.

2nd.—The air motion in the depression possessed several noteworthy features. The motion was extremely feeble in the central area (*i.e.*, up to distances of 200 miles at least from the apparent centre of wind convergence). This feature was even more strongly shown on the 24th, when the storm was most fully developed, the depression greatest and the gradients steepest, than when it was forming on the 21st and 22nd. Strong winds obtained only in the outskirts of the depression, more especially on the Sind coast. The strongest winds were however experienced at Quetta, Murree and Simla, showing that the cyclonic circulation was strongest in the higher strata at an elevation of probably 5,000 to 10,000 feet. The following gives the force of the winds at Quetta, Mount Abu and Murree, and at six plain stations for comparison:—

STATION.	WIND VELOCITY PER HOUR FOR 24 HOURS ENDING 8 A.M. OF						Normal velocity per hour in February.
	21st.	22nd.	23rd.	24th.	25th.	Mean of five days.	
Quetta	4	4	4	5	4	4·2	4
Murree	4	12	18	23	9	13·2	8
Mount Abu	5	10	15	17	9	11	6
Peshawar	3	2	2	2	6	3	3
Dera Ismail Khan	2	2	2	2	2	2	2
Mooltan	1	1	2	2	1	1·4	2
Lahore	1	2	4	10	2	3·8	2
Jeyapore	3	4	3	5	6	4	4
Kurrachee	15	18	20	20	11	17	11

3rd—One of the most remarkable features of the storm was the heavy rain which it gave in the districts to the north and north-east of the central depression, *i.e.*, to the Punjab and Punjab Himalayas and Afghan mountains. Although very strong south-westerly winds blow across the Sind coast, no rain fell in the south or south-east quadrants, and it is almost certain that these winds contributed very little to the excessive rainfall in the North Punjab, 200 miles in front of the centre on the 22nd and 23rd. The following gives a complete statement of the average and maximum rainfall in each district of the Punjab day by day during the storm:—

DISTRICT.	AVERAGE RAINFALL DURING 24 HOURS PRECEDING 5 P.M. OF FEBRUARY					HEAVIEST RAINFALL DURING THE PERIOD 20TH TO 24TH FEBRUARY		
	20th.	21st.	22nd.	23rd.	24th.	At station,	On day	Amount in inches.
	Inches.	Inches.	Inches.	Inches.	Inches.			
Hissar	...	...	...	...	0'68	Sirsa	24th	0'9
Rohtak	...	...	...	...	0'03	Rohtak	"	0'1
Gurgaon	...	...	...	...	0'01	Jatusana	"	0'1
Delhi	...	...	...	...	0'23	Sonepat	"	0'9
Karnal	...	...	...	...	0'52	Kaithal	"	2'0
Umballa	...	...	...	0'32	2'71	Naraingarh	"	6'7
Simla	0'02	0'08	0'40	1'22	2'47	Simla	"	3'8
Kangra	0'10	...	0'14	2'13	2'04	Dharmsala	23rd	3'5
						Palanpur	"	3'5
						Kulu	24th	3'5
						Nurpur	"	3'5
Hoshiarpur	...	...	0'04	0'84	2'32	Dasuya	"	3'8
Jullundur	...	...	0'13	0'55	1'38	Nawashahr	"	1'9
Ludhiana	...	...	...	0'23	1'30	Ludhiana	"	2'3
Ferozepore	...	...	...	0'21	0'99	Ferozepore	"	2'3
Mooltan	0'20	0'02	...	...	...	Mailsi	20th	0'4
Jhang	...	...	...	0'60	0'60	Chiniot	24th	1'4
Montgomery	...	...	...	0'73	0'13	Gugera	23rd	1'0
						Montgomery	"	1'0
Lahore	...	...	...	0'78	0'17	Meean Meer	24th	3'4
Amritsar	0'02	...	...	1'28	2'45	Jandiala	"	4'5
Gurdaspur	0'03	...	0'02	1'40	3'82	Shakargarh	"	5'4
Sialkot	...	...	0'04	0'64	1'94	Raya	"	3'2
Guzerat	...	...	...	0'60	1'03	Kharian	"	1'7
Gujranwala	...	...	0'26	1'02	0'54	Sadr Kacheri	"	1'4
Shahpur	...	...	...	0'28	0'55	Bhera	"	1'3

DISTRICT.	AVERAGE RAINFALL DURING 24 HOURS PRECEDING 6 P.M. OF FEBRUARY					HEAVIEST RAINFALL DURING THE PERIOD 20TH TO 24TH FEBRUARY		
	30th.	31st.	22nd.	23rd.	24th.	At station.	On day.	Amount in inches.
	Inches.	Inches.	Inches.	Inches.	Inches.			
Jhelum . . .	...	...	...	0'75	0'98	Sadr. Station . . .	23rd	1'6
Rawalpindi . . .	...	0'04	0'37	1'07	1'94	Rawalpindi . . .	24th	3'6
Hazara . . .	...	0'03	0'30	1'33	2'63	Abottabad . . .	"	4'1
Peshawar . . .	...	0'05	0'30	1'14	1'00	Lahore (Utman Balak) . . .	23rd	2'4
Kohat . . .	0'08	0'10	0'37	1'13	0'33	Hangu . . .	"	1'6
Banna . . .	...	...	0'05	0'38	...	Mianwali . . .	"	0'5
						Isa Khel . . .	"	0'5
Dera Ismail Khan . . .	...	...	0'16	0'08	...	Kulachi . . .	22nd	0'5
Dera Ghazi Khan . . .	...	...	...	0'43	0'03	Rajanpur . . .	23rd	0'7
Muzaffargarh . . .	...	...	...	0'20	0'07	Muzaffargarh . . .	"	0'3

The temperature relations were somewhat less marked than in the case of storms passing eastward across Northern India. The following gives temperature variation data for Northern India from the 23rd to the 27th:—

DISTRICT.	23rd.	24th.	25th.	26th.	27th.
Punjab	+2'5	—1'0	—3'2	—2'6	—1'8
Rajputana	+5'7	+5'7	—0'2	—2'8	—3'2
North-Western Provinces	+4'1	+4'9	+2'4	+1'4	—1'6
Central India	+4'3	+5'5	+2'7	+0'9	+2'1
Behar	—0'1	+1'4	+2'7	+2'7	+0'1
Bengal	—2'2	—0'1	+0'9	+2'3	+0'8
Assam	—0'5	—0'5	+1'6	+2'1	+2'2
Burma	—1'8	—1'5	—0'4	+0'9	+1'7

1889-90.

Chief abnormal features of the Meteorology of India in 1889.—The cold weather of 1888-89 was remarkable for the very heavy rainfall in Northern India, more especially in the Punjab. The snowfall in the higher mountain districts was however not excessive, and exercised little influence on the temperature and other conditions of the hot weather in India. Temperature was even higher than usual in Burma and Northern India, the excess being most marked in Bengal and Burma.

The south-west monsoon was slightly later in commencing in the south of the Arabian Sea, but it advanced with unusual rapidity in the second week of June, and was established

over the whole of India before the 13th. The rains continued with great steadiness throughout the remainder of June and in July and August, and there was no long break, such as frequently occurs in August. The rainfall was above the normal in all districts except the Punjab, Sind and Cutch, Guzerat and Burma: the deficiency was small in amount in the latter area. It averaged 13 per cent. in the Punjab. The rainfall was considerably in excess in the North-West Provinces, Behar, Rajputana, Orissa and the Circars, and the North Deccan, Hyderabad, Carnatic and Mysore.

The south-west monsoon currents withdrew from the Punjab in the first week of September. The retreating south-west monsoon rains commenced unusually late in the Madras coast districts. This was apparently due to the southerly and easterly advance of a strong and abnormally cool and dry current of air from the north-west frontier of India, which gave excessive pressure and very low temperature and humidity conditions in North-Western India and the Peninsula during the months of October and November. Hence the retreating south-west monsoon rains were very light during October and November in Madras (more especially the southern districts) Burma, and the Bay Islands on the other hand received considerably larger amounts than usual.

The following statement shows the variations of the rainfall from the normal during the south-west monsoon and retreating south-west monsoon periods:—

AREA.	1ST JUNE TO 30TH SEPTEMBER 1889.		PERIOD OF 1ST OCTOBER TO 31ST DECEMBER, 1889.	
	Variation of rainfall of period from normal.	Percentage variation.	Variation of rainfall of period from normal.	Percentage variation.
Western Himalayas	+ 9'82	+25	— 2'49	— 94
Punjab Plains	— 1'82	—12	— 1'11	—100
North-West Provinces and Oudh	+ 6'98	+21	— 1'45	— 34
Rajputana	+ 2'89	+13	— 0'39	— 68
Central India States	+ 0'68	+ 2	— 0'69	— 31
Behar	+ 6'15	+17	— 2'33	— 70
Western Bengal and Chota Nagpur	+ 0'19	0	+ 0'47	+ 12
Lower Bengal	+ 1'01	+ 2	+ 2'55	+ 48
Eastern Himalayas	+18'48	+20	— 2'59	— 45
Assam and Eastern Bengal	+ 5'61	+ 7	— 1'63	— 24
Orissa and Northern Circars	+ 1'74	+ 5	+ 7'43	+ 85
Central Provinces, South	+ 1'66	+ 4	+ 1'60	+ 52
Berar and Khandesh	+ 0'96	+ 3	— 0'25	— 6
Guzerat	— 1'34	— 4	+ 0'24	+ 21
Sind and Cutch	— 2'37	—31	— 0'15	— 47
North Deccan	+ 2'13	+10	+ 1'59	+ 25
Konkan and Ghâts	+ 7'04	+ 5	+ 1'66	+ 28
Malabar and Ghâts	+14'14	+16	+ 1'08	+ 9

AREA.	1st JUNE TO 30th SEPTEMBER 1889.		PERIOD OF 1st OCTOBER TO 31st DECEMBER 1889.	
	Variation of rainfall of period from normal.	Percentage variation.	Variation of rainfall of period from normal.	Percentage variation.
Hyderabad	+ 3'53	+14	+ 0'18	+ 4
Ceded Districts and Mysore	+ 7'97	+50	+ 0'92	+ 11
Carnatic	+ 4'36	+33	- 5'44	- 29
Nilgiri	+ 8'69	+56	- 2'87	- 13
Ceylon	+ 2'31	+12	- 9'57	- 32
Arakan	- 0'66	- 1	- 3'08	- 27
Pegu	- 2'40	- 4	+ 0'27	+ 3
Tenasserim	+ 3'89	+ 3	+ 7'57	+ 58
Upper Burma	+ 2'11	+ 7	+ 1'20	+ 24
Bay Islands	- 9'95	-14	+ 15'82	+ 58

The following were probably important factors in determining and modifying the cold weather rains of 1889-90 in India:—

1st.—The south-west monsoon rains were more abundant than usual, and on the whole were favourably distributed. The rainfall was in moderate defect in the frontier provinces of Sind and the Punjab, and largely in excess in Rajputana, the North-West Provinces and the greater part of the Peninsula.

2nd.—The retreating south-west monsoon rains were very abnormally distributed, Burma and the east of the Bay receiving heavy rain at the expense of the Madras coast districts.

3rd.—The prevalence of a very early and severe winter in the northern districts of Central Asia (Yarkand and the neighbourhood), with which was probably connected the slow advance of a cool and dry wave over India in October and November.

4th.—Pressure was in defect over the Indian area from October 1889 to July 1890. The following gives data for the first seven months of the period:—

Month.	Mean pressure variation of the whole of India.
September 1889	0
October "	—'033
November "	—'037
December "	—'016
January 1890	—'042
February "	—'002
March "	—'044
April "	—'004

5th.—Pressure at the hill stations was, when compared with the neighbouring plain stations, in relative excess. The following table gives data for six pairs of stations from September 1889 to March 1890:—

MONTH.	VERTICAL PRESSURE ANOMALY.					
	Leh and Lahore.	Quetta and Jacobabad.	Murree and Peshawar.	Simla and Ludhiana.	Ranikhet and Lucknow.	Darjeeling and Dhubri.
September 1889	—'016	?	+ '007	—'001	—'034	0
October "	+ '028	?	+ '014	—'002	+ '013	+ '032
November "	+ '068	+ '019	+ '022	+ '032	+ '035	+ '036
December "	+ '034	+ '042	+ '019	+ '042	+ '019	+ '036
January 1890	+ '073	+ '085	+ '029	+ '042	+ '014	+ '037
February "	+ '036	+ '042	+ '016	+ '032	+ '036	+ '046
March "	—'074	—'029	—'020	—'032	+ '015	+ '012
Mean of period September to February	+ '037	+ '047	+ '018	+ '024	+ '014	+ '031

The preceding data show that there was a largish excess of pressure in every month from October to February. The excess was on the whole greatest and most marked in the case of Quetta and Leh.

The chief features of the cold-weather months of January and February 1890 were the following:—

- 1st.—Deficient pressure over the whole Indian area. This deficiency of pressure was not a peculiarity of these two months, as it commenced in October 1889 and continued until July 1890.
- 2nd.—Increased temperature in Northern or Extra-Tropical India, which increased in amount with increase of elevation. The increase of temperature ranged from an average of $2\cdot3^{\circ}$ at the level of the plains of Northern India to $6\cdot3^{\circ}$ at the elevation of Leh (16,000 feet).
- 3rd.—Winds were steadier than usual in Northern India, and the westerly element was strongly marked in West and Central Bengal.
- 4th.—Abnormal dryness of the air. The abnormal dryness was greatest and most marked in Baluchistan, and not in the area of greatest increase of temperature in the higher Punjab Himalayan area.
- 5th.—The cloud amount was below the normal to a moderate extent.
- 6th.—The rainfall of the period was very largely in defect in Northern India, and the snowfall in the Himalayas considerably below its normal amount. The rainfall was largest, not only absolutely, but relatively to the normal, in the Punjab and adjacent hills. But even in these areas it was small in amount and much below the normal. In Rajputana, Central India, Bihar and West Bengal the rainfall of the period was practically nil.

The following gives rainfall variation data for the period 1st December 1889 to 31st March 1890:—

AREA.	PERIOD 1ST DECEMBER 1889 TO 31ST MARCH 1890.	
	Variation of rainfall of period from normal.	Percentage variation.
Western Himalayas	Inches. — 5'22	—51
Punjab Plains	— 2'13	—57
North-West Provinces and Oudh	— 1'64	—75
Rajputana	— 0'54	—71
Central India States	— 1'03	—63
Bihar	— 1'40	—85
Western Bengal and Chota Nagpur	— 1'33	—52
Lower Bengal	— 1'57	—50
Eastern Himalayas	— 3'14	—76
Assam and Eastern Bengal	— 1'43	—23
Orissa and Northern Circars	— 0'20	— 9
Central Provinces, South	— 1'22	—66
Berar and Khandesh	— 1'16	—79
Guzerat	— 0'27	—96
Sind and Cutch	— 0'74	—93
Arakan	+ 0'02	+ 1
Pegu	+ 0'60	+120
Tenasserim	+ 4'23	+220
Upper Burma	+ 0'31	?
Bay Islands	+13'40	+ 99

The following gives a summary of the snowfall data relating to the mountain districts of Northern India for the cold weather of 1889-90:—

- (a) There is slight evidence that over a considerable portion of Central Asia, including Yarkand, etc., the winter of 1889-90 was unusually severe and the snowfall probably excessive.
- (b) The amount of the snowfall was on the whole less than usual in the mountain region of Baluchistan and Afghanistan. The snow appears to have fallen in the early winter months of December and January, and to have melted rapidly in February and March.
- (c) The snowfall in the Western Himalayan area was unusually small in amount in the months of January and February, and probably normal in March. Very heavy snow fell during the last week of April, which influenced the weather conditions for a short time afterwards, but the snow rapidly melted in May, and the snow accumulation at the end of that month was considerably below the normal.

(d) The snowfall in the Eastern Himalayan regions was almost certainly less than usual.

Depression and cold-weather storm of January 20th to 25th.—This storm appears to have crossed Persia and Baluchistán. Bagdad had moderate showers on the 15th, 16th and 17th. The barometric and wind observations at that station are so doubtful that they cannot be utilised to establish the question of the origin or track of a storm. The Bushire observations indicate that a moderately deep depression passed a little to the north of that station on the 17th. The following gives the observations for the period 16th to 19th:—

DATE AND HOUR.	Barometer reduced to 32° sea-level and constant gravity.	Change in previous 24 hours.	Wind direction.	Amount of wind in previous 24 hours.	Rainfall previous 24 hours.
16th, 8 A.M.	30°010	—°025	NE	Miles. 39	Nil
17th, „	29°746	—°264	SE	117	Nil
18th, „	°895	+°149	N	433	Nil
19th, „	°977	+°082	N	141	Nil

The large fall on the 17th is further confirmed by the log of the *S.S. Pemba*, which was at Linga on the 16th and in latitude 26° 21' N. and longitude 51° 18' E., or midway between Linga and Bushire at noon of the 17th. Her barometer fell from 30°00" at noon of the 16th to 29°77" at noon of the 17th, and wind, which was from south-east during the day, shifted suddenly to north-west at 6 P.M. She had, however, moderate breezes and fine weather throughout the day. Hence, there appears to be sufficient evidence to establish that a depression crossed Persia on the 17th and 18th, and that the centre was perhaps near Bushire on the morning of the 17th. The available information, however, appears to establish that weather was not stormy, and that little or no rain fell in the storm area in South Persia. Squally weather was experienced on the 21st off the coast of Baluchistan by the *S.S. Cadler* and *Mobile*. The former had strong north-west winds, heavy squalls and thick rain, with thunder and lightning, during the day, and the latter on the night of the 20th and morning of the 21st had fresh north-west winds, with occasional rain-squalls and moderate sea, in about latitude 27° 5' N. and longitude 56° 25' E. The barometer in the case of these two vessels was steady.

The first indications of the advance of the storm across Baluchistan into India were given by the observations of the 20th, which showed that the barometer was falling rapidly at Quetta and on the North-West Frontier.

21st January.—The following 8 A.M. observations of the 21st indicate that the disturbance was then entering Sind:—

STATION.	BAROMETER.			WIND.		Cloud, 8 A.M.
	Corrected and reduced to 32° sea-level and constant gravity, 8 A.M.	Change since previous day.	Variation from normal.	Direction, 8 A.M.	Mean velocity previous 24 hours.	
Kurrachee	29°950	—°014	—°096	SSE	8	1
Jacobabad	°932	—°061	—°112	E	2	5
Quetta	?	—°016	—°014	S	3	10

Winds were increasing rather rapidly in force at Murree, and light showers had fallen in the North Punjab during the previous 24 hours.

22nd January.—The disturbance and depression was in Rajputana on the morning of the 22nd. The following observations show its position at 8 A.M. of that day:—

STATION.	BAROMETER.			WIND.		Cloud, 8 A.M.
	Corrected and reduced to 32° sea-level and con- stant gravity, 8 A.M.	Change since previous day.	Variation from normal.	Direction, 8 A.M.	Mean velocity previous 24 hours.	
Ajmere	29.956	—0.095	—0.087	W	5	0
Sirsa	897	—0.082	—150	SE	4	6
Montgomery	?	—0.020	?	E	7	10
Jacobabad	877	—0.055	—162	NW	3	0
Bickaneer	865	—0.092	?	S	5	6

The centre of the depression was hence to the west of Bickaneer. No rain had fallen in Sind or Rajputana during the previous 24 hours. Light to moderate rain had been received in the North and East Punjab, and snow in the hill districts, and a small and shallow subsidiary or secondary depression had formed in the East Punjab between Sialkot and the hills.

23rd January.—The primary depression continued to advance in an east by south course during the day, and its position at 8 A.M. of the 23rd is defined by the following:—

STATION.	BAROMETER.			WIND.		Cloud, 8 A.M.
	Corrected and reduced to 32° sea-level and con- stant gravity, 8 A.M.	Change since previous day.	Variation from normal.	Direction, 8 A.M.	Mean velocity previous 24 hours.	
Sutna	29.877	—0.102	—181	WNW	3	0
Allahabad	846	—0.110	—198	SE	2	0
Lucknow	851	—0.101	—192	E	2	7

The secondary depression in the East Punjab had moved slightly eastwards, but had not developed. Winds were light and irregular to the north-west of the primary depression. Skies had cleared in Sind and Rajputana, and clouded over in the western districts of the North-West Provinces. Rain had fallen in the East Punjab, and snow or rain in the Punjab and North-West Provinces hill districts.

24th January.—The primary depression on the morning of the 24th was in West

Bengal, Chota Nagpur and South Bihar. Its position and character are indicated by the following observations :—

STATION.	BAROMETER.			WIND.		
	Corrected and reduced to 32° sea-level and constant gravity, 8 A.M.	Change since previous day.	Variation from normal.	Direction, 8 A.M.	Mean velocity previous 24 hours.	Cloud, 8 A.M.
Burdwan	29.793	—'100	—'237	S	2	0
Berhampore	792	—'103	—'235	SSE	3	8
Purnea	816	—'080	—'213	ENE	2	8
Patna	846	—'029	—'202	N	3	10
Hazaribagh	808	—'077	—'202	WSW	8	0

The centre of the disturbance was probably in latitude 24° N. and longitude 87° E. Skies had cleared in the North-West Provinces, but were now more or less clouded in Bengal and Assam. Light showers had been received at the hill stations of the North-Western Provinces and at Simla, and near the hills in Bengal, Bihar and Assam, but the amounts were generally very small. The secondary depression had filled up during the previous 24 hours.

25th January.—The disturbance was in East Bengal on the morning of the 25th. The following observations define its position at 8 A.M. of that day :—

STATION.	BAROMETER.			WIND.		
	Corrected and reduced to 32° sea-level and constant gravity, 8 A.M.	Change since previous day.	Variation from normal.	Direction, 8 A.M.	Mean velocity previous 24 hours.	Cloud, 8 A.M.
Mymensingh	29.847	—'008	P "	ESE	6	10
Bogra	830	+ '012	P	N	3	0
Jessore	835	+ '008	—'180	NNW	4	10
Dacca	826	—'010	—'188	Calm	7	9
Barisal	866	+ '015	P	NW	3	8

Skies had cleared in West Bengal, Bihar and Chota Nagpur, but were now densely clouded in East Bengal and Assam. The depression was at this time passing through an area which had been characterised by very deficient pressure during the whole of the month, and it is not a little remarkable that the primary storm, which had previously practically been rainless, gave a fairly general and moderate burst of rain to Bengal. The following gives a statement of the rainfall of the previous 24 hours in Bengal :—

AREA.	Number of rain gauge stations.	Average rainfall of 24 hours preceding 8 A.M.	Heaviest rainfall in area.
East Bengal	42	Inch. 0.43	2.54 inches at Dacca.
North Bengal	40	0.10	0.70 " at Panch Bibi.
South-West Bengal	64	0.29	2.51 " at Narail.

The disturbance apparently filled up rapidly during the next 24 hours and entered Upper Burma, where it gave some light showers.

The depression gave dust storms and much thunder and lightning in North-Western India and light to moderate thunder showers in North-Eastern India.

The following gives approximately the position of the centre and rate of motion at different dates:—

DATE AND HOUR.	POSITION OF CENTRE.		Direction of motion.	Distance travelled since noon previous day.	Rate of motion per hour.
	Latitude North.	Longitude East.			
17th, 8 A.M.	30 7	50 7	...	miles.	miles.
21st, "	28	67	...	...	...
22nd, "	28	72 30	E	350	15
23rd, "	25 30	81 15	ESE	576	24
24th, "	24 15	87 15	ESE	400	17
25th, "	24 10	91 15	E	260	11

The following are noteworthy features of this storm:—

1st.—It almost certainly passed through Persia and Baluchistan.

2nd.—It crossed Northern India in an east by south track at a rate which varied considerably. Its rate was greatest when crossing Sind, Rajputana, the North-West Provinces and Bihar.

3rd.—It was, during the greater part of its existence, a rainless storm and gave moderate cloud, much thunder and lightning and numerous dust storms in North-Western India.

4th.—When passing through Bengal, an area in which pressure had been for some weeks previous characterised by local deficiency, it gave a moderate and general burst of rain.

5th.—It gave rise to a small secondary storm and depression in the East Punjab, the formation of which accompanied the occurrence of moderate rain in that area and the adjacent hill districts.

Depression of the 5th to 7th February.—The Bushire and Bagdad observations and the logs of vessels in the Persian Gulf at this time show that this depression did not cross Persia. The barometer fell upwards of a tenth of an inch in Sind and the West Punjab during the 24 hours preceding 8 A.M. of the 4th, the fall being almost identical in amount (*vis.*, 110") over the whole of that area. The majority of the stations in the area of greatest fall reported calms at that hour. The barometer continued to fall rapidly on the North-West Frontier during the next 24 hours, and a shallow depression covered Sind and the West Punjab on the morning of the 5th. The following data show the character of the disturbance:—

STATION.	BAROMETER.			WIND.		Cloud, 8 A.M.	Weather.
	Corrected and reduced to 32° sea-level and constant gravity, 8 A.M.	Change since previous day.	Variation from normal.	Direction, 8 A.M.	Mean velocity previous 24 hours.		
Kurrachee . . .	29.962	—107	—2094	N	9	1	Fine.
Hyderabad . . .	962	—108	—100	SW	7	3	Fine.
Jacobabad . . .	943	—127	—130	E	2	9	Fine.

6th February.—The depression advanced eastwards into Rajputana during the next 24 hours, and at 8 A.M. of the 6th the centre was near Bickaneer.

The following gives observations at the stations nearest the centre at that hour:—

STATION.	BAROMETER.			WIND.		Cloud 8 A.M.
	Corrected and reduced to 32° sea-level and constant gravity, 8 A.M.	Change since previous day.	Variation from normal.	Direction, 8 A.M.	Mean velocity previous 24 hours.	
Sirsa	29'982	—'073	—'068	SE	5	3
Montgomery	?	—'042	?	NE	9	6.5
Bickaneer	'923	—'078	?	S	5	4
Jacobabad	30'002	+ '059	—'079	NW	1	0
Ajmere	'068	—'051	—'009	SW	3	0

The depression was less in amount than on the previous day. The disturbance continued to fill up, and disappeared during the night of the 6th and morning of the 7th.

The disturbance gave no rain in the plains. Snow fell in the hill districts of the North Punjab and Baluchistan. The storm was throughout of small importance, and apparently originated near the North-West Frontier. During the brief period of its existence it marched in an easterly direction, a course occasionally adopted by depressions which originate in Baluchistan or North-Western India during the cold weather.

Pressure increased in Northern India after the disappearance of this depression, and was largely excess on the 8th and 9th. It decreased slowly and steadily during the next four days and on the 13th varied from the normal by small amounts over the whole of India. Pressure began to give way rapidly on the North-West Frontier and in Baluchistan during the next 24 hours. This was followed by the advance of the only important cold weather storm of the month.

Depression and cold weather storm of the 14th to the 17th February.—The Baghdad and Bushire observations and logs of vessels navigating in the Persian Gulf furnish no evidence of the advance of a storm and depression across Persia at this period. It is hence very probable that the depression originated in the table-land of Baluchistan. The barometer fell rapidly at Mooltan, Jacobabad and Quetta on the 13th, and on the morning of the 14th a shallow extensive depression covered Sind and Baluchistan. The following data show its character and position at 8 A.M. of the 14th:—

STATION.	BAROMETER.			WIND.		Cloud, 8 A.M.	Weather.
	Corrected and reduced to 32° sea-level and constant gravity, 8 A.M.	Change since previous day.	Variation from normal.	Direction, 8 A.M.	Mean velocity previous 24 hours.		
Kurrachee	29'942	—'041	—'074	W	8	5	Fine.
Hyderabad	'929	—'096	—'091	SW	6	10	...
Jacobabad	'917	—'105	—'117	E	2	4	Fine.
Quetta	?	—'100	+ '066?	SE	3	5	...

Skies were partially clouded in Sind and the Punjab, and were clear in other provinces of Northern and Central India.

15th February.—The barometer fell very rapidly in North-Western India during the next 24 hours, and the depression intensified considerably, but was almost unchanged in position. The following gives wind and pressure data of the Sind stations and Quetta for 8 A.M. of the 15th:—

STATION.	BAROMETER.			WIND.		Cloud, 8 A.M.	Weather.
	Corrected and reduced to 32° sea-level and constant gravity, 8 A.M.	Change since previous day.	Variation from normal.	Direction, 8 A.M.	Mean velocity previous 24 hours.		
Kutrachee . . .	29.788	—154	—228	WSW	12	4	Fine.
Hyderabad . . .	.758	—171	—258	SW	9	5	"
Jacobabad . . .	.725	—192	—301	SE	1	8	...
Quetta . . .	?	—083	—018	NNW	4	8	Strong wind.

The depression was now apparently one of considerable intensity, and the centre was near Jacobabad. Pressure had however given way on the 13th and 14th over the whole of India, and hence the gradients in the storm area were only moderately steep. Heavy showers of rain had fallen in the East Punjab, and fairly general rain or snow in the hill districts of the Punjab and North-West Provinces.

16th February.—The following stations define the area of greatest barometric depression on the 16th:—

STATION.	BAROMETER.			WIND.		Cloud, 8 A.M.	Weather.
	Corrected and reduced to 32° sea-level and constant gravity, 8 A.M.	Change since previous day.	Variation from normal.	Direction, 8 A.M.	Mean velocity previous 24 hours.		
Agra . . .	29.692	—172	—307	NW	6	5	Fine.
Lucknow . . .	.698	—164	—284	SE	3	5	Fine.
Allahabad . . .	.706	—177	—284	E	3	2	Fine.
Jhansi . . .	.670	—197	—298	SW	4	0	...
Jeypore . . .	.769	—098	—260	NW	3	0	...

Skies cleared on the 16th in Sind, Rajputana and the West Punjab, and were partially clouded in the North-West Provinces and East Punjab.

17th February.—The disturbance advanced eastwards and was in North and Central VOL. IV.

Bengal on the morning of the 17th. The following stations define the area of greatest barometric depression on that day :—

STATION	* BAROMETER.			WIND,		Cloud 8 A.M.
	Corrected and reduced to 32° sea-level and constant gravity. 8 A.M.	Change since previous day,	Variation from normal.	Direct ion, 8 A.M.	Mean velocity previous 24 hours.	
Burdwan	29.708	—'077	—'270	SW	3	0
Berhampore	711	—'075	—'270	SSE	3	0
Jessore	700	—'099	—'267	WSW	3	0
Dhubri	727	—'069	—'265	NE	4	0
Purnea	704	—'082	—'274	Calm	1	0

Skies were still much clouded in the North-West Provinces, but had cleared in the Punjab. There was little or no cloud in Bengal. The depression filled up slowly in Bengal on the 17th and 18th, but pressure continued more or less below the normal during the remainder of the month.

The weather in India during the month of March was very disturbed, and several very shallow and feeble depressions the tracks of which are hence not given in the track chart of the season, appeared in North-Western India. Pressure was increasing in Upper Sind and the Punjab at the commencement of the month. It increased slightly and unequally in Western India and decreased in Kathiawar and Guzerat on the 2nd. In consequence of these changes a feeble depression lay over Guzerat and Kathiawar on the morning of the 3rd. It moved eastwards into Central India and the Central Provinces on the 4th, and into Bihar and the south-eastern districts of the North-Western Provinces on the 5th, and disappeared during the day. The depression was throughout a very feeble one, and the cyclonic circulation accompanying it was very imperfectly developed. The disturbance, notwithstanding, gave light to moderate rain to the East Punjab, North-West Provinces, East Rajputana, Bihar, Central India, and the eastern districts of the Central Provinces. Pressure gave way rapidly on the 7th and 8th, and small local disturbances appeared which gave thunderstorms in Bengal, Guzerat and Southern India on the 9th. Slightly disturbed conditions, chiefly shown by very irregular barometric changes, continued until the 16th, during which period Assam and East Bengal received daily light showers. On the 17th a depression formed in Sind, which gave a period of disturbed weather to Northern India until the 21st or 22nd.

The depression which had formed in Sind on the 17th intensified slightly during the next 24 hours. The pressure changes at this time show clearly that the depression had not advanced eastwards from Baluchistan, but was due to the large and somewhat irregular pressure changes of the period in North-Western India. The depression advanced slowly westwards into Western Rajputana on the 19th, and into the Central Provinces and Chota Nagpur on the 20th, and filled up in North-Eastern India on the 21st and 22nd. The weather was more or less disturbed (with thunderstorms and duststorms) in Northern and Central India during the whole period. Scattered showers were received in the North-West Provinces on the 18th, in Bengal, the North-West

Provinces and South-East Punjab on the 19th, in the East Punjab on the 20th, and in the North-West Provinces and Punjab on the 21st, but the amounts were nowhere large.

1890-91.

Chief abnormal features of the meteorology of India in 1890.—The cold weather of 1889-90 was unusually dry and free from storms. The hot weather months of March, April and May were drier and hotter than usual in Northern India. The south-west monsoon rains set in earlier than usual on the Bombay coast and at their normal date on the Bengal coast. They advanced more rapidly than usual into the interior, and were fully established over the whole of India in the beginning of the fourth week of June. The rains were unusually abundant in June and July, and on the whole normal but unequally distributed in August and September. The rainfall of the south-west monsoon period was hence normal or in excess over by far the greater part of India. The excess was greatest, relatively to the normal, in Bihar (34 per cent.), the Punjab, Orissa, Bengal and the Konkan (slightly exceeding 10 per cent.). The rainfall of the period was practically normal in the Central Provinces and the Deccan. It was in moderate defect in Upper Burma, Guzerat and Sind and Southern India. The chief features in the relative distribution of rainfall during the south-west monsoon period were hence very persistent and strongly marked, and the variations from month to month were due mainly to changes in the general strength of the monsoon currents.

The monsoon rains terminated slightly later than usual in North-Western India and about their normal date in North-Eastern and Central India. They were hence favourably distributed with respect to time, as well as their extension.

The rainfall of the retreating south-west monsoon was marked by the most striking and characteristic features of the year:—

1st.—The retreating south-west monsoon current withdrew from the Bay in the last week of November, or three weeks earlier than usual. The current gave rain, either normal in amount or in moderate excess, during the months of October and November to the Peninsula. The early withdrawal in the last week of November caused the rainfall of the period in South Madras (more especially in the South Coromandel districts) to be considerably in defect.

2nd.—The most remarkable feature of the period was the absence of cyclonic storms in the bay.

3rd.—Weather was unusually stormy in the Afghan mountains and Western Himalayas and heavy snow began to fall much earlier than usual.

The following gives a statement of the rainfall variations from the normal during the period 1st June to 31st December:—

AREA.	PERIOD FROM 1ST JUNE TO 30TH SEPTEMBER 1890.		PERIOD FROM 1ST OCTOBER TO 31ST DECEMBER 1890.	
	Variation of rainfall from normal.	Percentage variation.	Variation of rainfall from normal.	Percentage variation.
Western Himalayas	+11'05	+29	+1'41	+51
Punjab Plains	+2'56	+16	+1'59	+137

AREA.	PERIOD FROM 1ST JUNE TO 30TH SEPTEMBER 1890.		PERIOD FROM 1ST OCTOBER TO 31ST DECEMBER 1890.	
	Variation of rainfall from normal.	Percentage variation.	Variation of rainfall from normal.	Percentage Variation.
North-West Provinces and Oudh	+10'98	+33	-1'14	-69
Rajputana	-2'21	-10	-0'02	-4
Central India States	+4'32	+11	-1'54	-72
Bihar	+14'74	+39	-1'23	-38
Western Bengal and Chota Nagpur	+4'44	+10	-0'80	-91
Lower Bengal	+2'84	+6	+3'39	+98
Eastern Himalayas	+27'49	+26	+7'18	+111
Assam and Eastern Bengal	+6'39	+8	+0'97	+14
Orissa and Northern Circars	+4'14	+11	+0'68	+8
Central Provinces South	+2'01	+4	+0'35	+11
Berar and Khandesh	+1'51	+5	+0'06	+1
Guzerat	-4'53	-15	-0'85	-73
Sind and Cutch	-1'30	-17	+2'43	+593
North Deccan	-1'25	-6	+3'45	+53
Konkan and Ghats	+19'92	+15	-1'48	-25
Malabar and Ghats	-14'29	-16	-3'86	-91
Hyderaad	+3'43	+13	-0'35	-8
Ceded Districts and Mysore	-1'30	-8	+0'90	+11
Carnatic	+1'79	+14	-4'94	-21
Nilgiris	-1'32	-10	-1'99	-9
Ceylon	-6'17	-33	-7'65	-22
Arakan	-7'75	-6	-3'93	-35
Pegu	-4'75	-8	-1'02	-11
Tenasserim	-15'59	-11	-4'32	-34
Upper Burma	-8'51	-31	+0'44	+9
Bay Islands	-11'10	-16	-4'59	-18

The following were probably the most important features determining or modifying the precipitation and weather of the cold-weather season of 1890-91:—

- 1st.—The prevalence of a strong and unusually steady monsoon from June to the end of September.
- 2nd.—The abnormally early withdrawal of the retreating south-west monsoon currents from the Bay at the end of November.
- 3rd.—The absence of cyclonic storms in the Bay during the retreating south-west monsoon period.

4th.—The prevalence of conditions in Central Asia which determined the commencement of heavy snowfall in the mountain region to the North-West of the Punjab several weeks earlier than usual.

5th.—Pressure was steadily throughout the period in moderate excess in the Indian area. The following gives data:—

MONTH.	Variation of mean pressure of Indian area from normal.
1890, September	—'009
October	+ '003
November	+ '030
December	—'004
1891, January	+ '005
February	+ '022
March	+ '015

This excess was not large, and was hence not an important feature of the period.

6th.—The prevalence of very abnormal pressure relations between the hill stations and the plain stations, indicating a large deficiency of pressure at the level of 7,000 to 10,000 feet in Northern India and an excess at the same elevation in Southern India. The following gives data for six pairs of stations:—

MONTH.	VERTICAL PRESSURE ANOMALY.					
	Leh and Lahore.	Quetta and Jacobabad.	Murree and Peshawar.	Simla and Ludhiana.	Ranikhet and Lucknow.	Darjeeling and Dhubri.
	"	"	"	"	"	"
September 1890	—'018	+ '025	+ '008	+ '009	—'004	—'017
October "	—'014	+ '012	—'017	+ '006	+ '012	+ '007
November "	—'002	—'035	—'026	+ '004	+ '001	—'031
December "	—'038	—'066	—'033	+ '003	+ '028	—'016
January 1891	+ '012	—'034	—'030	+ '008	+ '021	+ '032
February "	—'070	—'054	—'070	—'043	—'021	—'013
March "	—'107	—'070	—'056	?	—'047	—'034
Mean of period	—'034	—'032	—'032	—'002	—'001	—'010

Chief features of the meteorology of the cold weather period of 1890-91.—The following gives a brief summary of the weather in November 1890 to March 1891.—Weather was disturbed in November with more or less frequent rain in Baluchistan and Afghanistan and North-Western India, more especially the North and West Punjab, and unusually early and heavy snow fell on the higher elevations. Disturbed weather continued in North-Western India throughout December, and unusually heavy snow was also received in that month on the Western Himalayas and the Afghan mountains, and heavy rain in the Punjab. Thus, the West Punjab received an average total rainfall of 1'6 inches, its normal average in December being only '3 inch.

The weather was unusually disturbed in Upper India in January. Three disturb-

ances appeared in, and passed across North-Western India and gave heavy rain in Northern India and much snow in the mountain districts to the north and north-west.

The weather in February was on the whole somewhat less disturbed than in January. Two large disturbances, the first extending over the 1st to the 5th, and the second from the 19th to the 22nd, gave heavy rain to the plains of Northern India, and very heavy snow in the North-Western Himalayas. In the interval between these two disturbances there was a period of unsettled weather in Madras and Southern India, during which numerous thunderstorms occurred, which gave rain in many districts where it was urgently required after the prolonged drought of December and January. The temperature of the month was below the normal over the whole of Northern and Central India. The deficiency ranged from 3° to 5° over the greater part of the North-West Provinces and the Punjab, and was absolutely greatest in the hills at Murree ($6\frac{1}{2}^{\circ}$) and in the plains at Peshawar ($5\frac{1}{2}^{\circ}$). It was, on the other hand, in moderate excess in Assam, Burma and the Peninsula to the south of latitude 18° N. The deficiency in the temperature in Northern India was chiefly due to unusually low day temperature.

The conditions were even more abnormal in March than in the preceding two months. A depression appeared in North-Western India on the 10th, and gave much rain in the Punjab. It was immediately after followed by a very remarkable disturbance in Bengal, Bihar and the North-West Provinces, which gave a very unusual and general burst of rain on the 12th, 13th and 14th. During this period an average amount of about 3 inches fell in Bihar and West Bengal in which the average rainfall of the whole month is less than half an inch. The month was remarkably cool over the whole of Northern and Central India. The mean temperature in Northern India was below the normal by amounts varying from 3° in East Bengal to $8\frac{1}{2}^{\circ}$ at Lahore.

The following table gives comparative data of the precipitation during the cold weather period 1st January to the 31st March 1891:—

PROVINCE.	DIVISION.	COLD-WEATHER RAINFALL FOR PERIOD 1ST JANUARY TO 31ST MARCH 1891.	
		Variation from normal.	Percentage, from normal Variations.
BURMA	Tennasserim	Inches. —0·26	— 22
	Lower Burma	—0·25	— 40
	Central do.	—0·10	— 36
	Arakan	+0·54	+ 106
	Eastern Bengal	—0·02	0
	Assam (Surma)	—6·93	— 58
BENGAL AND ASSAM	Do. (Brahmaputra)	—1·42	— 22
	Deltaic Bengal	+2·89	+ 79
	Central do.	+4·31	+ 104
	North do.	+1·43	+ 53
	Orissa	+2·56	+ 111
	Chota Nagpur	+4·47	+ 182

PROVINCE.	DIVISION.	COLD-WEATHER RAINFALL FOR PERIOD 1ST JANUARY TO 31ST MARCH 1891.	
		Variation from normal.	Percentage Variation from normal.
		Inches.	
BENGAL AND ASSAM— <i>contd.</i>	Berar (South)	+3'40	+241
	Do. (North)	+2'69	+183
	North-West Provinces (East)	+0'96	+65
	Oudh (South)	+1'55	+122
	Do. (North)	+1'25	+69
NORTH-WEST PROVINCES AND OUDH.	North-Western Provinces (Central)	+0'74	+60
	Do. do. (West)	+0'01	+1
	Do. do. (Submontane)	+0'96	+29
	Punjab (South)	+2'00	+108
PUNJAB	Do. (Central)	+1'45	+69
	Do. (Submontane)	+3'06	+77
	Do. (Hill Districts)	+1'49	+14
	Do. (North-West)	+4'64	+83
	Do. (West)	+1'22	+65
CENTRAL PROVINCES AND BERAR	Berar	+0'67	+72
	Central Provinces (West)	+0'42	+41
	Do. (Central)	+0'28	+17
	Do. (East)	+3'38	+215
BOMBAY (NORTH)	Guzerat	-0'09	-69
	Kathiawar	-0'15	-38
	Sind	+0'53	+63
RAJPUTANA AND CENTRAL INDIA	Central India (East)	-0'16	-21
	Rajputana (East), Central India (West)	+0'70	+121
	Rajputana (West)	+0'04	+8

The following gives the chief facts respecting the snowfall of the winter of 1890-91 in the Himalayan and Afghan mountain districts :—

- (1) The snowfall in the mountain regions of Baluchistan and Afghanistan was very much above the average. The winter began early in November and continued unusually late, and snow fell at frequent intervals and in large amounts during the whole of that period.
- (2) The winter was exceptionally severe and prolonged in the Western Himalayas bordering the Punjab and the North-West Provinces. The first considerable snowfall occurred in November, and snow fell more or less steadily throughout the whole season up to nearly the end of May. The amount received in the lower ranges was generally (except in the North Punjab) not

much greater than usual, but on the higher interior ranges it was very excessive and over the greater part of the area much heavier than the snowfall of 1885, and also than that of 1887 and of 1878. So far as it can be judged from the reports, it appears to be almost certain that an average fall of 40 feet, if not considerably more, was received over all the higher ranges from Murree eastwards to Garhwal, and perhaps to Central Nepal.

- (3) The snowfall in the Eastern Himalayas was over a considerable part of it, certainly less than usual, and over the whole area was either normal or in defect.

Depression and cold weather storm of the 25th to the 28th December.—

The observations at Bagdad and Bushire from the 22nd to the 24th indicate that weather was very unsettled with strongish winds and rain. The following gives Bushire observations of this period:—

DATE.	Barometer reduced to 32° sea-level and constant gravity.	WIND.		Mean temperature.	Rain previous 24 hours.
		Direction.	Mean velocity previous 24 hours.		
22nd	29.991	SE	9	61.6	Inches. 2.67
23rd	29.937	NW	9	57.4	0.28
24th	30.207	NE	11	52.0	Nil

Weather was very disturbed at this time in the Persian Gulf and head of the Arabian Sea. The S.S. *Kilwa* experienced, on the morning of the 23rd, in about Lat. $26\frac{1}{2}^{\circ}$ N. and Long. $56\frac{1}{2}^{\circ}$ E., a strong gale, high confused sea, and heavy rain. On the 24th the same vessel was at Bunder Abbas. She had during the afternoon a strong gale and squally weather, and on the 25th at Linga she had a fresh to strong gale. The S.S. *Simla*, from Lat. $26\frac{1}{2}^{\circ}$ N., Long. $54\frac{1}{2}^{\circ}$ E., on the 23rd, to her arrival at Bahrein on the 24th, had a moderate to fresh gale, frequent squalls, and a high sea. It is hence probable that a shallow but extensive cyclonic disturbance was propagated eastwards through Persia and Baluchistan between the 21st and 24th. On the other hand, the barometric changes in Baluchistan and the North-West Frontier stations were very irregular on the 23rd and 24th, and appear to be opposed to the suggestion of the advance of a definite cyclonic storm (in the lowest atmospheric strata) across Baluchistan. The barometer was low at Murree on the morning of the 24th, and strong south-east winds were blowing at that station on the morning of the 25th. A very shallow secondary depression, with its centre near Montgomery, at that hour overlay the South-West Punjab and Upper Sind. The circulation in the area of depression was irregular, and the storm was of little importance, judging from the amount and extent of the depression only. Moderately heavy rain had nevertheless fallen in the North Punjab, and heavy snow in the hill districts. The depression was transferred to the eastern districts of the North-West Provinces and the adjacent districts of the Central Provinces and Chota Nagpur on the 26th, where pressure had fallen from one to two-tenths of an inch. It then passed into North and Central Bengal on the 27th, but was then filling up rapidly and it disappeared during the next 24 hours. The storm gave no rain on the 26th and 27th. The depression was

throughout too ill defined to enable the track to be laid down with even approximate certainty.

(II.) *Depression and cold-weather storms of January 7th to 10th.*—The weather at Bushire in the Persian Gulf was unsettled between the 2nd and 6th. The barometer was very unsteady, and frequent showers fell, giving a total of 3·27 inches of rain during this period. There was, however, no cyclonic shift of wind at that station, the wind directions varying irregularly between north and east. It is hence very probable that the present depression did not advance as a cyclonic storm across Persia. The barometer was fairly steady and high in India at the commencement of the month, and marked anti-cyclonic conditions prevailed. It began to fall on the 5th, the fall being most rapid in North-Western India. Gradients were very small on the 6th, and winds light and unsteady in Northern India. Nine out of eleven plain stations, and the hill stations of Quetta and Murree reported calms on the morning of the 6th. The observations of that date indicate that a shallow depression was forming in, or advancing across Afghanistan, as the barometric changes of the previous 24 hours were greatest at the following stations:—

STATION.	BAROMETER.			Cloud amount.	WIND.	
	Actual corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction.	Average velocity during previous 24 hours in miles per hour.
Peshawar	30'125	—'061	—'019	1	Calm	1
Rawalpindi	'121	—'050	—'026	0	Calm	1
Dera Ismail Khan	'119	—'030	—'017	4	Calm	1
Quetta	...	—'057	+ '003	3	Calm	0

These observations of the 6th appear to establish that the disturbance was at this time small and of little importance. The barometer fell during the next 24 hours over the whole of Burma and India, with the exception of Malabar and Konkan, but the changes were small except in North-Western India, where they slightly exceeded '05. The following gives data of the 7th for the stations where the fall was greatest:—

STATION.		BAROMETER.			Cloud amount.	WIND.	
		Actual corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction.	Average velocity during previous 24 hours in miles per hour.
PLAIN STATIONS.	Rawalpindi	30'044	—'077	—'075	10	NE	2
	Peshawar	'062	—'063	—'061	10	ESE	2
	Lahore	'071	—'053	—'046	2	Calm	1
HILL STATIONS.	Quetta	...	—'023	—'014	4	Calm	2
	Murree	...	—'027	+ '019	10	SSE	9
	Simla	...	—'016	?	10	N	?
	Leh	...	—'056	...	8	S	0

The preceding observations suggest rather the formation of a disturbance in the north of the Punjab than the advance of a well-defined depression from Afghanistan. The large increase of cloud in the Punjab and at the Punjab hill stations, and the increasing

orce of the winds at Murree (more especially when compared with Quetta) indicate that he slight disturbance was increasing in intensity. The 8 A.M. is abnormal of this day in Upper India were nearly parallel to the North-West Frontier, and suggest the formation in the West Punjab, West Sind and adjacent districts of Afghanistan and Baluchistan of a long shallow trough of low pressure. The barometric changes of the next 24 hours were large and significant. They are given in the following table for certain stations, the observations of which establish that a deepish depression covered the south-east of the Punjab on the morning of the 8th :—

STATION.		BAROMETER.			Cloud amount.	WIND.	
		Actual corrected for sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction.	Average velocity during previous 24 hours in miles per hour.
PLAIN STATIONS.	Sialkot	29'944	—'118	—'145	9	W	2
	Lahore	'946	—'125	—'161	10	N	3
	Ludhiana	'876	—'193	—'215	9	W	1
	Sirsa	'867	—'208	—'207	3	WSW	4
	Delhi	'942	—'160	—'158	9	NW	2
	Roorkee	'922	—'177	—'162	10	W	1
HILL STATIONS.	Quetta	...	+ '019	+ '014	0	Calm	3
	Murree	...	—'158	—'134	10	ESE	21
	Simla	...	—'158	—'178	10	SSE	?
	Leh	...	—'225	...	10	SW	0

The most striking fact in these observations is the very large fall of the barometer at the hill stations, and more especially at Leh, where it was actually greatest, although that station is at an elevation of nearly 12,000 feet above sea-level. Skies had cleared during the previous 24 hours in the South-West Punjab and Baluchistan, but were overcast in the East Punjab and adjacent hill districts. Light to moderate rain, averaging 0.2 inch had fallen in the Punjab, and light to moderate snow in the hills during the previous 24 hours.

The depression was transferred to the east-south-east during the next 24 hours, and was in Bihar and the eastern districts of the North-West Provinces at 8 A.M. of the 9th. Its position is fixed by the following observations :—

STATIONS.		BAROMETER.			Cloud amount.	WIND.	
		Actual corrected for sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction.	Average velocity during previous 24 hours, in miles per hour.
Hazaribagh		29'939	—'114	—'128	0	SW	5
	Patna	'933	—'088	—'159	0	S	1
	Benares	'878	—'135	—'209	0	ENE	3
	Allahabad	'942	—'064	—'151	0	Calm	4

The depression was now filling up and was of little importance. Winds were very light in Bengal, Bihar and the North-West Provinces, and continued to blow from north-east or east on the Bengal coast. There was still much cloud in the Punjab, but skies were, as hitherto, clear in the eastern districts of the North-Western Provinces and Bihar. With the exception of a few light local showers in the Punjab, no rain had fallen in Northern India during the previous 24 hours. The barometer in-

creased rapidly during the day in North-Eastern India) *i.e.* in the eastern district of the North-Western Provinces, Bihar, Bengal and Assam), and the depression completely filled up before 8 A.M. of the 10th.

The disturbance was hence a comparatively feeble one. It cannot be decided from the observations whether it originated in the north-west frontier districts or passed across Afghanistan and Baluchistan as a very shallow and insignificant depression, and entered India as a long and narrowish belt or trough of low pressure. It is on the whole most probable that it consisted of a shallow primary disturbance which began to give rise to a secondary depression when crossing the frontier. The combination of these two disturbances gave rise on the 8th to the trough of low pressure. In either case the disturbance developed rather rapidly on the 7th, and was a fairly well defined depression on the morning of the 8th. It advanced eastward and filled up on the afternoon and evening of the 10th in North-Eastern India. The track of this storm is not given in the track chart of the season.

A most important feature of the cold-weather storms which enter North-Western India from Baluchistan and Afghanistan is that they are usually extremely feeble and shallow depressions before entering India, but that they occasionally develop rapidly under varying conditions in Northern India into important and deep depressions and are then attended with very heavy rain and snow in Upper India. This appears to be mainly due to the fact that, when crossing Persia and Baluchistan, they are maintained by a comparatively dry upper current which has passed over the extensive land region of North Africa and Arabia, whereas after they enter India, the upper south-west or west south west current over the Arabian Sea begins to feed into them. This is a comparatively moist current and hence modifies the character and conditions of the storm. It is probable the present disturbance was an example of this class of storm.

(III). *Depression and storm of January 15th to 17th.*—Fine clear weather prevailed for some days after the disappearance of the previous depression over the whole of India, with the exception of the Punjab, where skies continued to be more or less clouded. The barometer rose steadily and rather rapidly in North-Western India, and was considerably above its normal height on the 12th. The excess was greatest in the Indus Valley between Peshawar and Jacobabad, where it averaged a sixth of an inch. No important change occurred, until the 14th, when pressure began to give way over the whole of India, the fall being greatest in the Indus Valley. This fall immediately preceded the appearance of the second cold-weather storm of the month.

The following observations for 8 A.M. of the 15th indicate the character of the incipient disturbance on that date:—

STATION.		BAROMETER.			Cloud amount. ³	WIND.	
		Actual corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction.	Average velocity during preceding 24 hours in miles per hour.
PLAINS OF UPPER INDIA.	Peshawar . . .	30°131	—°139	+°013	8	SSW	2
	Dera Ismail Khan . .	30°131	—°116	+°014	2	SW	1
	Mooltan . . .	30°135	—°108	+°033	5	NNW	1
	Jacobabad . . .	30°109	—°117	+°033	7	SE	1

STATION.		BAROMETER.			Cloud amount.	WIND.	
		Actual corrected to 32° F.	Change in preceding 24 hours.	Variation from normal of day.		Direction.	Average velocity during preceding 24 hours in miles per hour.
HILLS OF UPPER INDIA.	Quetta	24'715	—'064	+ '043	8	Calm	3
	Murree	23'919	—'054	+ '059	8	ESE	3
	Simla	23'104	—'044	+ '013	1	ENE	?
	Leh	19'804	—'007	?	8	Calm	0

The following table gives the average cloud amount at 8 A.M. of the 14th and 15th and the average velocity of the air movement during the 24 hours preceding each of these dates in five provinces of Northern India :—

PROVINCE.	WIND VELOCITY IN MILES PER HOUR.			CLOUD AMOUNT.	
	Normal, January.	Actual, 14th.	Actual, 15th.	8 A.M., 14th.	8 A.M., 15th.
Punjab ⁶	1'9	2'0	2'7	1'5	5'2
Sind	6'3	11'0	9'7	1'0	5'7
Rajputana	4'2	2'7	2'3	0	2'7
North-Western Provinces	2'3	3'7	4'3	0	0'6
Bihar	2'0	2'3	2'5	1'00	0

The preceding data show that at this time the air movement was feeble and differed little from the normal, and that cloud was forming rapidly in Upper India. No rain fell on the 14th in Northern India.

The barometer fell rapidly on the 15th, and a deepish depression overlay the Punjab on the morning of the 16th, the centre of which was near Montgomery. The following data show the character and position of the disturbance :—

		STATION.	BAROMETER.			Amount of cloud.	WIND.	
			Actual corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction.	Average velocity during previous 24 hours in miles per hour.
PLAIN STATIONS, UPPER INDIA.	{	Jacobabad	29·825	—·284	—·245	10	NW	4
		Mooltan	·814	—·321	—·277	10	NW	1
		Montgomery . . .	·780	—·350	—·320	10	E	8
		Lahore	·844	—·271	—·237	10	E	2
		Khushab	·809	—·310	—·290	10	Calm	1
		Dera Ismail Khan .	·821	—·310	—·278	10	Calm	1
HILL STA- TIONS, UPPER INDIA.	{	Quetta	...	—·248	—·204	10	Calm	3
		Murree	...	—·241	—·186	10	SE	17
		Simla	...	—·108	—·121	10	SE	?
		Leh	...	—·208?	?	5	S	0

These observations show that a rapid development of the disturbance had taken place in the Punjab during the previous 24 hours, and indicate that this was not due to the advance of a deep depression from Afghanistan and Baluchistan, but to the intensification of the depression which had commenced to form in the preceding day in the Punjab itself. The fact that the fall of the barometer was almost the same in amount at Leh and Murree as at Quetta (the distance of these two stations from Quetta being approximately 700 and 500 miles respectively) appears to establish that the disturbance was a very extensive one, and that it affected the atmosphere to a very great height and that the sphere of condensation and of the chief development of the storm was in the higher strata and atmospheric currents. The average air movement in the Punjab, Sind, and Rajputana during the previous 24 hours was actually less (about 5 per cent.) than on the 14th. Skies were now very heavily clouded in Upper India. The cloud amount had increased to 10 (overcast) in the Punjab, to 8·0 in Sind and to 7·2 in Rajputana. Moderately heavy rain had fallen in the Punjab and Sind, and some snow at Quetta and Murree. The weather was becoming very stormy with unusually strong winds in the Punjab Himalayan districts.

The barometric changes during the next 24 hours and the distribution of pressure on the morning of the 17th were complicated and indicated that there were now two centres of disturbance and two independent areas of low pressure. The first, the centre of which was near Roorkee, was almost certainly the continuation of the disturbance of the 16th. The following give data for this depression:—

STATION.		BAROMETER.			Amount of cloud.	WIND.	
		Actual corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction.	Average velocity during previous 24 hours in miles per hour.
PLAIN STATIONS.	Meerut	29·874	—·112	—·178	10	SE	8
	Roorkee	838	—·162	—·213	8	SE	10
	Dehra Dun	859	—·141	?	9	SE	3
	Ludhiana	903	+·003	—·176	9	S	7
	Lahore	867	+·023	—·216	3	SE	9
HILL STATIONS.	Mussoorie	...	—·045	?	10	E	?
	Chakrata	...	—·065	?	10	NE	17
	Simla	...	—·142	—·262	10	SSW	?
	Leh	...	—·275	?	10	E	0

These observations show that at the level of the plains the greatest fall of the barometer and the lowest pressure was at Roorkee. The winds at 8 A.M. were, however, comparatively light over the area of depression, and were from south-east at all stations, thus showing that at the level of the plains there was no definite cyclonic circulation. The most remarkable fact is the much larger fall of the barometer at Leh than at any other station, further proving that the chief seat of activity of this storm was at a very great elevation. The absence of a well marked cyclonic circulation in this depression was in part at least due to the appearance of a second depression on the North-West Frontier.

The barometer had again fallen in Baluchistan and the South-West Punjab and had risen slightly at Lahore and other stations in the area between the two depressions.

The following gives data of this second depression at 8 A. M. of the 17th :—

STATION.		BAROMETER.			Amount of cloud.	WIND.	
		Actual corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction.	Average velocity during preceding 24 hours in miles per hour.
PUNJAB AND SIND PLAINS.	Peshawar	29.836	—'023	—'273	10	NE	8
	Dera Ismail Khan . .	'800	—'021	—'302	8	Calm	1
	Mooltan	'780	—'034	—'317	0	SE	2
	Jacobabad	'824	—'001	—'251	0	Calm	9
HILL STATIONS.	Quetta	...	—'059	—'262	3	Calm	5
	Murree	...	—'122	—'305	10	?	38

The weather was now exceedingly stormy in the hill districts, and the Murree observer telegraphed that a tremendous snow-storm was raging at that station. Stormy weather with strong winds prevailed over the whole of the Punjab, Rajputana and the western districts of the North-Western Provinces, and very heavy rain had fallen over the greater part of that area. An excessively heavy fall of snow occurred over the whole of the Punjab Himalayas at this time, as is indicated by the snowfall reports given in the next section.

Rain continued to fall for some hours after 8 A. M. of the 17th in Upper India after which the barometer began to rise with unusual rapidity, and before 8 A. M. of the 18th, both depressions had completely disappeared, and marked anti-cyclonic conditions with fine weather, light winds or calms and clear skies were again established over Northern India. The following data for 8 A. M. of the 18th show the character of this change :—

STATION.		BAROMETER.			Amount of cloud.	WIND.	
		Actual corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction.	Average velocity during previous 24 hours in miles per hour.
HILL STATIONS.	Quetta	...	+ '268	+ '018	0	Calm	1
	Murree	...	+ '273	— '030	5	ENE	17
	Simla	...	+ '179	— '080	0	ESE	9
	Leh	...	+ '130	?	10	WSW	3
PLAIN STATIONS.	Peshawar	30.240	+ '404	+ '116	3	Calm	4
	Lahore	'221	+ '354	+ '126	0	Calm	4
	Roorkee	'196	+ '358	+ '106	0	Calm	7
	Jeyapore	'230	+ '276	+ '084	0	W	5
	Jacobabad	'237	+ '413	+ '170	0	NW	2
	Mooltan	'239	+ '459	+ '142	0	NNE	1

The barometer continued to rise on the 18th, and on the morning of the 19th was normally high, and the highest pressures of the month were recorded in Upper India on

that day. The following gives the highest readings of the barometer reduced to sea-level:—

STATION.	BAROMETER.	
	Actual corrected to sea-level and constant gravity.	Variation from normal of day.
Peshawar	30'334	+ '211
Mooltan	'306	+ '217
Jacobabad	'323	+ '264

The following points appear to be worthy of notice in connection with the preceding storm:—

- 1st.—The Bushire observations appear to indicate that, a disturbance similar in character but much less intense, affected Southern Persia two or three days previously to the present disturbance. The following gives these observations:—

DATE.	BAROMETER.		WIND, 8 A.M.	Rainfall, previous 24 hours.
	Actual corrected to sea-level and constant gravity.	Change in preceding 24 hours.		
January 12th	30'067	—'044	E	...
" 13th	'073	+ '006	SE	...
" 14th	'046	—'027	SE	2'52
" 15th	'248	+ '202	NW	Nil.

- 2nd.—The Leh observations indicate that the barometric movements during this disturbance were greater at that station than at any other hill station, and that the fall of the barometer during the storm was absolutely greater there than at the plain stations in India.

The following table gives the barometric data of Leh during this period:—

MONTH.	DATE.	HOUR.	Actual barometer reduced for temperature.	Change since to A.M. of previous day.	Approximate variation from mean of period.
January	14	10 A. M.	19.822	+ '032	+ '1 48
"	15	"	'804	—'018	+ '130
"	16	"	'574	—'230	—'100
"	17	"	'336	—'238	—'338
"	18	"	'471	+ '135	—'203
"	19	"	'722	+ '251	+ '048

The fall and rise of the barometer during this disturbance, so far as it can be determined by observations taken a fixed hour daily, are given for a number of stations in Upper India in the following table in order to show approximately the amplitude of the barometric oscillation during the storm:—

	Quetta.	Murree.	Leh.	Peshawar.	Mooltan.	Lahore.	Roorkee.	Jacobabad.
Total fall of barometer from 14th to 17th .	—'378	—'417	—'486	—'434	—'463	—'369	—'278	—'402
Total rise of barometer from 17th to 19th .	+ '348	+ '359	+ '386	+ '498	+ '526	+ '366	+ '353	+ '499

The figures show, that the barometric movement was greater at Leh than at Murree, and greater at Murree than at Quetta. The total fall of the barometer at Leh was also greater than at any plain station in Upper India. The full significance of these figures rests mainly on the facts, that Leh is at an elevation of nearly 12,000 feet (11,503 feet) and is separated from the Punjab plains by a barrier of mountains, upwards of 150 miles in width, the higher ranges of which exceed 20,000 feet in elevation. The atmospheric disturbances and movements of Northern India are consequently not limited to India by the mountain mass of the Himalayas, but affect the districts to the north of the Himalayas, and they do this because the atmospheric disturbances of the cold weather usually originate and move in the middle and higher strata of the atmosphere. In this respect, as in several others, the storms of the cold weather are entirely different from those of the rains.

This storm was an interesting one in many respects. The evidence is, on the whole, in favour of a depression having advanced eastwards across Persia and Baluchistan, from the latitude of Bushire (on the 13th) to the South-West Punjab (on the 16th). It was, however, a feeble storm until it entered the Punjab, when it developed rapidly and advanced eastwards to the Garhwal or North-West Provinces Himalayas, near or over which it apparently broke up. During the period that it increased rapidly in intensity an exceptionally heavy fall of snow was received in the Western Himalayas and heavy rain in the Punjab. The observations at Murree and Leh establish fully that the storm was essentially one of high elevation, and that its development in the Punjab was almost certainly due to the influx, at a high elevation, of a moist upper current from the south or south-west, as in the previous storm, and that the condensed vapour was deposited as snow or rain to the north and east of the storm area, the higher elevations, on the southern flank of the Himalayas, receiving the largest amounts.

(IV.) Depression and storm of the 22nd to the 25th January 1891.—The barometer fell continuously on the 19th, 20th and 21st, the fall being as usual greatest in North-Western India and decreasing in amount eastwards and southwards. In consequence of these changes pressure was very uniform in Northern India on the morning of the 22nd, and light winds and calms generally prevailed. Skies gradually clouded over in Northern India during this period. The following average data illustrate the steady gradual increase of the cloud amount :—

PROVINCE OR AREA,	AVERAGE CLOUD AMOUNT AT 8 A.M. OF THE			
	19th.	20th.	21st.	22nd.
Hill Stations, Upper India	1'0	4'4	5'4	9'8
Punjab	0	3'1	3'6	9'1
Sind	2'0	0'7	6'7	10'0
Rajputana	0	0'3	5'7	7'0
Central India	0	0	0'8	0'5
North-Western Provinces	0'8	3'4	2'9	5'9
Bihar	0	0	0	1'0

The preceding data show clearly the gradual development of cloud with the fall of the barometer. Some light local showers had fallen in the Punjab during the 24 hours preceding 8 A.M. of the 22nd, but there was as yet no definite depression in Upper India shown by the actual distribution of pressure, although a shallow one was indicated by the isabnormals. During the next 24 hours, a remarkable change occurred. Heavy rain fell over the Punjab, the North-Western Provinces, and Rajputana, and light rain in Sind, the largest amounts being received in the districts near the Punjab Himalayas. The barometer fell most rapidly in Sind on the 20th and in Rajputana on the 21st, and the isabnormals suggest that a very shallow but extensive depression was passing eastwards through Sind and Rajputana on these days. The barometer fell rapidly in this area, and a depression was formed which was deepest at 8 A.M. of the 23rd at Sutna and Allahabad.

The following data show the position and character of the depression at that hour :—

STATION.	PRESSURE.			Amount of Cloud, 8 A.M.	WIND.	
	8 A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.
Allahabad	29.915	—'129	—'127	10	ENE	6
Lucknow	'966	—'084	—'082	10	NE	4
Cawnpore	'897	—'119	?	10	NE	5
Jhansi	'933	—'083	—'105	8	NNW	4
Saugor	'907	—'062	—'113	5	SW	7
Sutna	'893	—'127	—'155	10	S	8

These observations establish that a shallow depression, the centre of which was probably a little to the south-east of Cawnpore, was now passing eastwards through the central and eastern districts of the North-Western Provinces and the adjacent districts of the Central Provinces. It was almost certainly the continuation of the very shallow depression which had crossed Sind and Rajputana during the previous 48 hours. The following gives the corresponding observations of the hill stations in Northern India :—

STATION.	PRESSURE.		Amount of Cloud, 8 A.M.	WIND.	
	Change in preceding 24 hours.	Variation from normal of day.		Direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.
Murree	—'034	—'096	9	Calm	3
Simla	—'122	—'212	10	Calm	?
Leh	—'079	?	10	Calm	0
Chakrata	—'134	?	10	E	5
Ranikhet	—'075	—'064	10	E	5

Moderate rain had fallen during the previous 24 hours in the Punjab, Sind, Rajputana, Oudh and the western districts of the North-Western Provinces. Thunder-storms and hail-storms were reported by many stations.

The observations up to this stage hence appear to indicate that the disturbance entered India as a very shallow but somewhat extensive disturbance, which gave very little rain until it reached Central India and Rajputana, when the storm received a considerable development which accompanied a general moderate rainfall, largest in amount to the north and north-east of the central area of depression and in the neighbourhood of the hills.

The 8 A.M. observations of the 24th show that the disturbance had advanced eastwards during the previous 24 hours and was then in Central Bengal. The barometer had risen very rapidly in North-Western and Central India and had fallen moderately in Central Bengal.

The following observations indicate the position and character of the disturbance at this time:—

STATION.	PRESSURE.			Amount of cloud, 8 A.M.	WIND.	
	8 A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.
Dhubri	29'981	—'095	—'040	10.	E	11
Mymensingh	'948	—'098	?	6	Calm	3
Bogra	'952	—'084	?	10	Calm	3
Jessore	'969	—'067	—'048	0	Calm	3

Unusually heavy rain had fallen in Bihar and Chota Nagpur, and light to, moderate rain in North and Central Bengal, the North-Western Provinces and the East Punjab. At Patna $2\frac{1}{4}$ inches were registered at 8 A.M. and at Gaya $1\frac{3}{4}$ inches. The preceding observations show that the depression was much shallower than on the previous day, and that the air motion was very slight.

The barometer rose during the next 24 hours in Northern India, the rise being greatest in Central Bengal, for which it averaged nearly a tenth of an inch; but a slight fall in Burma indicated that the depression continued to advance eastwards at the same time that it was filling up. There is no evidence of its existence in the observations of the 25th.

The disturbance hence passed from Baluchistan and Sind on the 21st into Rajputana on the 22nd, the eastern districts of the North-Western Provinces on the 23rd, Central Bengal on the 24th and Upper Burma on the 25th, and hence advanced across Northern India with a fairly regular motion of about 450 miles per diem. It was of little importance, except for a period of about 36 hours on the 22nd and 23rd, when its intensity was considerably and temporarily increased during a period of moderate rainfall extending over a large part of Northern India, and of moderate snowfall on the Himalayan area.

Anti-cyclonic conditions were re-established in Northern India on the 26th, on which day fine clear weather with light westerly winds generally prevailed in Northern India. Skies were clouded, and the weather was somewhat unsettled in the Punjab. The barometer fell in that area on the 27th and light showers were received, chiefly in the northern districts. Weather was fine with a rising barometer on the 28th, but pressure began to give way generally on the 29th and decreased steadily on the 30th and 31st, the fall being greatest on the North-West Frontier.

(V.) *Cyclonic storm of the 1st to the 5th February 1891.*—At the end of the month of January the barometric movements were small and such as obtain in fine, settled weather. The observations of the 31st of January showed that pressure was decreasing briskly on the North-West Frontier. The following gives a summary of the pressure and cloud data of the 31st of January:—

PROVINCE.	PRESSURE.		Average amount of cloud at 8 A.M.
	Change in preceding 24 hours.	Variation from normal of day.	
Punjab	—'031	+ '016	3'6
Sind	—'052	—'024	0
Rajputana	—'008	+ '017	0
North-West Provinces	+ '001	—'027	0'4
Guzerat and Central India	—'001	+ '001	0'3
Central Provinces and Berar	+ '021	+ '018	0
Bengal	+ '001	—'061	1'0
Bombay	+ '025	+ '008	0
Madras	+ '021	—'015	1'6
Burma	—'028	—'111	1'0

The barometric changes given above and at Quetta indicate that a very slight disturbance was affecting Sind and Baluchistan. Skies were partially clouded in Baluchistan and clear in Sind, but were rapidly clouding over in the Punjab.

The barometer fell over the whole of India during the next 24 hours, the fall being largest in Sind and Baluchistan and diminishing in amount eastwards and southwards. At the same time a large increase of cloud occurred in the Punjab, Sind, and the North-West Provinces. The following table gives a summary of the more important pressure data for the 1st February:—

PROVINCE.	PRESSURE.		Average amount of cloud at 8 A. M.
	Change in preceding 24 hours.	Variation from normal of day.	
Punjab	—'164	—'151	9'6
Sind	—'199	—'232	7'0
Rajputana	—'144	—'122	0'3
North-West Provinces	—'079	—'111	2'8
Guzerat and Central India	—'110	—'104	0'6
Central Provinces and Berar	—'077	—'059	0
Bengal	—'053	—'120	0'4
Bombay	—'061	—'051	0
Madras	—'053	—'072	2'0
Burma	—'017	—'130	1'9

The chart for the day shows that a moderate depression overlay Upper Sind, the centre of which was probably near, and to the south-west of Jacobabad. The following gives data of the stations in and near the area of depression:—

STATION.	PRESSURE.			Amount of cloud, 8 A.M.	WIND.	
	8 A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.
Jacobabad	29'791	—'241	—'274	3	ESE	2
Mooltan	'864	—'217	—'204	10	NE	1
Hyderabad	'837	—'193	—'224	10	NE	4
Kurrachee	'851	—'162	—'198	8	ESE	5
Peshawar	'873	—'253	—'199	10	W	4
Quetta	P	—'239	—'248	3	SSW	2
Murree	P	—'154	—'115	10	ESE	13

The wind directions of these stations are extremely irregular, and show that at this stage there was no cyclonic circulation in Sind or Baluchistan. Winds were very feeble and skies very lightly clouded at Quetta and Jacobabad. The chief development of cloud was in fact in the Punjab and Western Himalayas, and the large increase of the strength of the wind at Murree clearly indicated that the only area in which the cyclonic action was increasing was the North Punjab. Hence the observations of the 31st and 1st establish that a moderate disturbance appeared in Sind and Baluchistan, and was marching eastwards, and that a secondary disturbance was developing in the North Punjab. An examination of the Bushire, Baghdad and Meshed observations shows clearly that the disturbance did not enter Baluchistan from Persia. It hence almost certainly originated in Baluchistan and Sind.

The observations of the next 24 hours indicate that the secondary disturbance in the North Punjab developed with great rapidity, and at 8 A.M. of the 2nd a deep depression overlay the Punjab, which obscured the shallower depression advancing eastward across Northern India from Sind.

The following gives the pressure changes and cloud amounts of the 2nd:—

PROVINCE.	PRESSURE.		Average amount of cloud, 8 A.M.
	Change in preceding 24 hours.	Variation from normal of day.	
Punjab	—'323	—'460	9'0
Sind	+ '022	—'217	0
Rajputana	—'190	—'288	4'0
North-West Provinces	—'107	—'201	4'2
Guzerat and Central India	—'062	—'174	1'7
Central Provinces and Berar	—'061	—'112	0
Bengal	+ '028	—'092	0'5
Bombay	—'014	—'065	0'5
Madras	—'001	—'077	1'6
Burma	+ '041	—'087	'9

These pressure changes in Northern and Central India are at once explicable on the supposition of the advance of the primary disturbance into Eastern Rajputana and the development of a deep secondary disturbance in the North Punjab. The following gives data for stations in the central area of the secondary disturbance in the Punjab:—

STATION.		PRESSURE.			Amount of cloud, 8 A.M.	WIND.	
		8 A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.
PLAIN STATIONS	Peshawar	29'546	—'327	—'533	10	SSE	3
	Dera Ismail Khan	'525	—'375	—'545	8	S	2
	Kushab	'543	—'353	?	8	SSW	4
	Lahore	'530	—'341	—'512	10	SE	6
	Sialkot	'502	—'408	—'506	6	E	6
	Rawalpindi	'454	—'446	—'548	10	SW	3
HILL STATION	Murree	...	—'385	—'499	10	SE	33

These observations show that a low pressure area, in which the barometer was upwards of five-tenths of an inch below the normal, lay over the north and centre of the Punjab, and that the depression was almost as large at Murree as at the level of the plains. Winds although somewhat irregular, were, on the whole, cyclonic in direction at the plain stations, but were comparatively feeble, whilst at the elevation of Murree they were the same in direction as at the level of the plains below, but were very violent, and in fact stormy cyclonic winds. It is hence a striking example of the cyclonic storms of high elevation to which the cold weather storms of Northern India chiefly, if not exclusively, belong. Heavy rain had fallen over the greater part of the Punjab and heavy rain or snow in the Punjab hills, thus showing that ascensional movement had been very active over that region during the previous 24 hours.

The presence of the primary depression in East Rajputana is very feebly indicated by the peculiar southern bend of the isobars in that area, shown in the weather chart of the day. The following gives data of the stations in the area:—

STATION.	PRESSURE.			Amount of cloud, 8 A.M.	WIND.	
	8 A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.
Ajmere	29'754	—'200	—'291	6	W	11
Jeypore	'761	—'177	—'275	0	SE	2
Jhansi	'802	—'133	—'218	0	SW	4
Agra	'799	—'176	—'255	4	SW	6

The gradients in North-West India at 8 A.M. of this day were very steep, and such as usually accompany very strong winds. In the primary depression the winds were very

light and irregular in direction. Skies were either clear or very lightly clouded, doubtless partly, if not mainly, due to the indraught to the deep secondary depression. The barometric movements of the next 24 hours were also very large in amount. A very rapid rise occurred in North-Western India due to the filling up of the secondary depression in the Punjab. The primary depression hence again came into prominence and was now in Bihar and the south-eastern districts of the North-Western Provinces, having drifted about 400 miles during the previous 24 hours. The following table gives data showing the general character of the pressure changes in India of the previous 24 hours :—

PROVINCE.	PRESSURE.		Average amount of cloud at 8 A.M.
	Change in preceding 24 hours.	Variation from normal of day.	
Punjab	+ '363	— '125	4·2
Sind	+ '153	— '067	0
Rajputana	+ '218	— '118	0
North-Western Provinces	+ '059	— '154	1·4
Guzerat and Central India	+ '098	— '091	0·3
Central Provinces and Berars	+ '017	— '099	0
Bengal	— '034	— '126	0·9
Bombay	+ '024	— '040	0·1
Madras	+ '003	— '074	1·1
Burma	— '014	— '100	2·3

The chief change was hence the very rapid rise in Upper India, and, as shown by the chart of the day, the filling up of the depression with, as might be expected, a large decrease in the amount of cloud. Light north-westerly winds and calms now prevailed in the Punjab. The position of the only depression now in existence is defined by the following observations :—

STATION.	PRESSURE.			Amount of cloud, 8 A.M.	WIND.	
	8 A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.
Hazaribagh	29·874	— '039	— '122	0	S	7
Patna	'862	— '045	— '159	2	E	4
Benares	'834	— '046	— '188	7	ENE	4
Allahabad	'848	— '009	— '183	0	WNW	4
Sutna	'886	+ '030	— '147	0	W	5

The shallow depression in the south-eastern districts of the North-Western Provinces and the adjacent districts of Bihar was evidently the continuation of the disturbance which had crossed Rajputana, as it resembled it in all its important features, whilst it

differed entirely in character from the depression in the Punjab on the 2nd. It was in fact a very shallow, dry or rainless depression, accompanied with light to moderate winds and a very slight development of cloud.

Light to moderate showers had fallen in the Punjab and north-western districts of the North-Western Provinces and heavy snow in the Western Himalayas. Elsewhere none had fallen, and hence the rainfall of the previous 24 hours was primarily due to, and accompanied the disturbance in the Punjab.

Pressure continued to increase in North-Western India during the next 24 hours, and the shallow depression moved eastwards at approximately the same rate as hitherto, and was in North and Central Bengal at 8 A.M. of the 4th. The following table gives data showing the pressure changes of the previous 24 hours:—

PROVINCE.	PRESSURE.		Average amount of cloud, 8 A.M.
	Change in preceding 24 hours.	Variation from normal of day.	
Punjab	+ '102	— '032	3'0
Sind	+ '037	— '029	6
Rajputana	+ '093	— '046	0'7
North-Western Provinces	+ '082	— '085	0'5
Guzerat and Central India	+ '041	— '037	0'1
Central Provinces and Berar	+ '030	— '090	0
Bengal	— '066	— '184	1'6
Bombay	— '020	— '061	0
Madras	— '046	— '122	1'7
Burma	— '038	— '146	1'2

Pressure was now normal or slightly in defect in North-Western and Central India. The brisk fall in Bengal was due to the transfer of the shallow depression to that area. Its position is given by the following observations:—

STATION.	PRESSURE.			Amount of cloud, 8 A.M.	WIND.	
	8 A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.
Purnea	29'778	— '091	— '227	0	SW	2
Dinajpur	'755	— '140	?	0	SW	2
Jaipalguri	'739	— '156	?	0	...	2
Dhubri	'754	— '138	— '244	0	SW	6
Sibsagar	'798	— '087	— '246	10	SW	2
Darjeeling	?	— '096	?	0	SW	9

These observations show that the depression was fairly well marked and that it had advanced about 400 miles during the previous 24 hours. They also indicate that the depression now probably lay over the Bhutan and Sikkim hills, as the winds at Darjeeling,

at a height of nearly 8,000 feet, were the same in direction as at the nearest stations in the plains of Bengal, but were considerably stronger. No rain had fallen during the previous 24 hours and skies were clear over the area of depression. The depression filled up quickly during the next 24 hours, and the Sibsagar observations alone show a trace of its existence at 8 A.M. of the 5th.

The following gives roughly the position of the central depression of the primary disturbance from day to day during its existence :—

DATE.	Area of central depression.	POSITION.		Distance travelled over during previous 24 hours.
		Lat. N.	Long. E.	
February 1st	Sind	27½	69½	Miles. ...
" 2nd	Rajputana	26½	75½	370
" 3rd	Bihar	25½	82	430
" 4th	Bengal	26	88½	390
" 5th	East Assam	26½	94	420

These positions are of course only approximate, but they show that the disturbance moved on an easterly course across Northern India, from Sind to Assam, with a fairly uniform velocity, averaging about 400 miles daily.

The following are the more important features of the depression :—

- (a) It was throughout a shallow depression, but advanced across the whole breadth of Northern India at a fairly uniform rate of about 18 miles an hour.
- (b) It was during the greater part of its existence a dry depression, and not only gave no rain but the greater part of the depression area was free from cloud.
- (c) The phenomena of the storm are easily explicable on the supposition that it was a whirl in the steady westerly current of the higher atmospheric strata, which is one of the most important features of the cold-weather circulation of Northern India.
- (d) When entering Sind from Baluchistan it gave rise, probably by drawing upon the upper humid current from the equatorial regions of the Arabian Sea, to cloud and rainfall and much ascensional movement in the north-eastern quadrant by the local action of the Himalayan mountains. This led to the rapid formation of a deep depression in the Punjab, which, however, filled up as rapidly as it formed, and only influenced the primary depression by clearing the skies and depriving it of much of its aqueous vapour.
- (e) The primary depression was unchanged in character until it got entangled amongst the high mountain ranges to the north of Sikkim and Bhutan, when it was speedily broken up.

From the 6th to the 11th February pressure continued to increase in North-Western India. The most rapid rise occurred on the 10th, on which day pressure increased nearly two-tenths of an inch in the Punjab, and was abnormally high on the morning of the 11th.

The following gives 8 A.M. pressure data of that day for the two stations at which pressure was most excessive:—

STATION.	PRESSURE.		
	8 A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.
Peshawar	30'459	+ '181	+ '344
Dera Ismail Khan	30'455	+ '203	+ '374

The only occasion on which a higher pressure has been recorded in the Punjab, during the past 13 years, was on January 5th, 1886, at 10 A.M., when a pressure of 30'493" was recorded at Dera Ismail Khan. On the same day and hour a pressure of 30'453" was registered at Mooltan, and 30'445" at Lahore. This excessive pressure in Upper India on the 10th and 11th of the month appeared to strengthen the north-east winds in the Bay of Bengal, and to produce an unusual influx of damp easterly winds into the Peninsula (chiefly the most southern districts), which gave slightly unsettled weather with frequent thunder-storms and rain. During the period of excessive pressure from the 10th to the 18th, both the Central Provinces and the Peninsula south of Lat. 15° N. received almost daily rain, chiefly as local thunder-showers. On the 18th the barometer, which was varying from two-tenths in the Punjab to a twentieth of an inch in Southern India, began to fall rapidly in Northern India and briskly in the Peninsula, and fine, settled weather set in again over the Peninsula, whilst a disturbance commenced in North-Western India.

The following gives barometric data of the 19th:—

PROVINCE.	PRESSURE.		AVERAGE AMOUNT OF CLOUD AT 8 A.M.	
	Change in preceding 24 hours.	Variation from normal of day.	18th.	19th.
Punjab	— '192	— '057	8'6	7'6
Sind	— '162	— '007	1'7	10'0
Rajputana	— '161	— '028	3'0	4'0
North-Western Provinces	— '182	— '045	1'3	1'5
Guzerat and Central India	— '118	— '006	0'7	2'0
Central Provinces and Berar	— '125	— '013	1'3	0'4
Bengal	— '149	— '033	1'3	1'7
Bombay	— '079	+ '007	0	0'7
Madras	— '089	+ '014	2'8	1'4
Burma	— '085	— '012	0'7	1'4

This large fall of the barometer over the whole of India immediately preceded the formation of a depression in the Punjab. On the 17th and 18th pressure was highest and also most excessive in Upper Sind. On the 18th, as stated above, pressure decreased

very rapidly over the whole of India, due apparently in part to a general expansional movement. The changes were largest in the area extending along the foot of the hills from Ludhiana to Meerut and the adjacent hill districts. The following gives data for 8 A.M. of the 19th in illustration:—

	STATION.	PRESSURE.			WIND.	
		Change in preceding 24 hours.	Variation from normal of day.	Amount of cloud, 8 A.M.	Direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.
PLAIN STATIONS . . .	Ludhiana . . .	—'211	—'099	8	W	4
	Dehra Dun . . .	—'239	?	7	Calm	1
	Meerut . . .	—'220	—'075	3	W	4
	Quetta . . .	—'097	+ '028	7	Calm	0
HILL STATIONS . . .	Murree . . .	—'114	+ '014	8	ENE	9
	Simla . . .	—'186	—'092	10	NW	...
	Mussoorie . . .	—'186	?	7	NNW	...
	Ranikhet . . .	—'156	—'034	0	Calm	5
	Darjeeling . . .	—'116	?	10	Calm	3

Hence the barometric observations show that there was a tendency to slight disturbance in the South-East and Central Punjab.

(VI.) Depression and cold weather storm of the 20th to the 22nd February 1891.—The barometer fell over the whole of India during the next 24 hours, but the fall was not large, except in North-Western India, where it accompanied the formation of a deepish depression in the Punjab. The following gives data illustrating the barometric movements throughout India during the 24 hours preceding 8 A.M. of the 20th:—

PROVINCES.	PRESSURE.		Average amount of cloud, 8 A.M.
	Change in preceding 24 hours.	Variation from normal of day.	
Punjab	—'235	—'270	77
Sind	—'234	—'246	87
Rajputana	—'224	—'226	93
North-Western Provinces	—'073	—'123	58
Guzerat and Central India	—'113	—'126	96
Central Provinces and Berar	—'079	—'097	54
Bengal	—'023	—'057	40
Bombay	—'055	—'050	26
Madras	—'064	—'050	15
Burma	+ '002	0	27

The position of the depression is shown by the following observations:—

STATION.	PRESSURE.			Amount of cloud, 8 A.M.	WIND.	
	8 A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.
Khushab	29°68g*	—°292	?	6	E	3
Montgomery	°678	—°316	?	6	E	6
Moolan	°705	—°297	—°338	5	NE	1
Jeypore	°828	—°180	—°213	10	WNW	3
Sirsa	°719	—°251	—°293	8	SE	6
Lahore	°737	—°227	—°231	10	SE	2

The winds showed a fairly complete cyclonic circulation, but it was as yet moderate in amount. The observations indicate that the centre of the barometric depression and cyclonic circulation, was to the south of Montgomery. No rain had fallen except, in the Kashmir hills and at Murree, Quetta, and Rawalpindi, and the amounts at these stations were not large. The concentration up to this stage had hence not accompanied heavy rain.

The barometer rose slightly during the next 24 hours over the greater part of India, but the changes were of little importance, except in Upper India, where they were due to the transfer of the depression into the South-East Punjab. The following observations define its position at 8 A.M. of the 21st:—

STATION.	PRESSURE.			Amount of cloud, 8 A.M.	WIND.	
	8 A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.		Direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.
Sirsa	29°693	—°026	—°333	0	W	7
Ludhiana	°703	—°054	—°312	6	SE	8
Lahore	°734	—°003	—°299	2	NE	5
Montgomery	°745	—°067	?	4	N	6

Snow had fallen generally in the hill districts and sporadic showers in the Punjab plain, but no general rain had occurred in the central area of depression. For example, the preceding 48 hours had been rainless at Montgomery, Khushab, Lahore and Sirsa. Rain, it may be noted, fell chiefly in the districts at the foot of the hills, and hence at a very considerable distance to the north of the central depression. Skies had cleared to the west of the depression, and were very lightly clouded in the central depression itself. If the centre was near and to the south of Montgomery on the 20th and north of Sirsa on the 21st, as the observations indicate, it had advanced not more than 100 miles in an east-south-east or east by south track during the 24 hours from 8 A.M. of the 20th to the same hour of the 21st.

* This observation was wrongly given as 29°639 in the India Weather Report.

The barometer rose during the day over the whole of India, except in Bengal and Orissa. The rise was greatest along the foot of the hills from Peshawar to Roorkee. The depression of the 21st broke up on approaching the hills of the South-East Punjab. The fall in Bengal was apparently caused by an influx of moist winds from the head of the Bay. The effect of the changes was to give a trough or belt, of low pressure, extending in a curve from Lower Sind to the north-western districts of the North-West Provinces and thence to the Orissa Coast. General rain had fallen during the previous 24 hours over the greater part of Bengal, and skies were heavily clouded over the Gangetic plain from the Bengal Coast to the centre of the North-West Provinces, but were clear or lightly clouded elsewhere. A further increase of pressure occurred during the day over the whole of India which was large in Upper India, and small in Bengal and the Peninsula. Well-marked anti-cyclonic conditions were hence established on the morning of the 23rd in Upper India, but a shallow depression covered South-West Bengal and Orissa.

The distribution of pressure was very unusual for the season, and the weather was generally disturbed in North-Eastern India, and numerous thunder-storms, in some cases attended with severe hail, had visited Bengal, Bihar and the eastern districts of the North-West Provinces, in which fairly general rain was received. The barometer again rose during the day and further emphasized the existing anti-cyclonic or high pressure conditions in Upper India. The depression was much less marked in South Bengal and Orissa on the morning of the 24th, and the weather improved rapidly during the day. Some showers were received in Orissa.

Pressure began to give way rapidly on the North-West Frontier on the 25th, which initiated a very slight disturbance in the Punjab on the 26th. It gave fairly general rain on that day to the greater part of that province. Pressure increased slightly on the 26th in North-Western India. No large or important change occurred during the remainder of the month, but weather conditions continued in a slightly unsettled condition, with local showers.

The disturbance of the 20th and 21st was noteworthy in several respects, more especially the following:—

1st.—It apparently originated in the Punjab. The Indian or Baluchistan observations of the 18th to the 20th furnish no evidence of the passage of a deep depression from Afghanistan into the Central Punjab. On the other hand, the Bushire observations show that a depression passed across Southern and Central Persia between the 15th and 18th. The following gives the Bushire observations:—

DATE.	PRESSURE.		WIND.	
	S A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Direction, S A.M.	Average velocity in miles per hour during previous 24 hours.
15th	30.048	+ .002	N	4
16th	29.838	— .210	SE	4
17th	28.20	— .018	S	3
18th	27.21	— .099	SE	6
19th	27.92	+ .271	NW	20

2nd.—Bushire is about 1,200 miles west of Lahore. It is very improbable that the depression, which passed eastwards to the north of Bushire on the 17th and 18th, should be the same as that which appeared in the Central Punjab on the morning of the 20th. It is, on the other hand, possible that a general feeble disturbance and very shallow depression may have been rapidly transmitted eastwards across East Persia, Afghanistan, and Baluchistan from the 16th to 19th, and that local conditions in the Punjab caused a large development of the disturbance when it reached that area for a period of about 48 hours, after which it rapidly broke up on reaching the high ground of the Himalayas. The supposition cannot, however, be verified in the almost entire absence of observations in the area to the north-west of India.

3rd.—The rapid development of the depression on the 19th and its equally rapid disintegration on the 21st.

4th.—The absence of rainfall in the central depression and in the area to the south of it, and the occurrence of moderate to heavy snow or rain in the hills and the submontane districts to the north of the central depression, in which respects it resembled the larger storms which drift across Northern India from Sind to Bengal.

5th.—These features of the storm suggest that the geographical features of the Punjab are largely influential in contributing to the rapid development of cold-weather storms in Upper India.

(VII.) Depression and storm of the 11th to the 15th March 1891.—The following observations show the character and position of the depression on the 11th:—

STATION.	PRESSURE.			WIND.		Amount of cloud, 8 A.M.
	8 A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.	Direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.	
	"	"	"			
Mount Abu	29.957	-.078	-.143	SW	.7	0
Deesa	29.799	-.094	-.152	NW	8	2
Ajmere	.835	-.052	-.144	S	4	5
Montgomery	.856	-.036	?	ENE	12	9
Mooltan	.792	-.136	-.157	Calm	1	4
Jacobabad	.821	-.056	-.092	Calm	4	10
Hyderabad	.821	-.047	-.117	NW	12	10

The depression, although well marked, was shallow and the cyclonic circulation feeble at the stage.

The Bushire observations establish that a very shallow depression passed eastwards to the north of that station on the 7th and 8th, and it is possible that the present disturbance may have been the continuation of that depression. This appears further to be

confirmed by the fact that there was a continuous fall of the barometer for three days during the passage of the depression at Bushire similar to, but smaller in amount than that which occurred in Northern India before, during the appearance of the storm. This is shown fully by the following data:—

BAROMETRIC CHANGES DURING 24 HOURS PRECEDING 8 A.M. OF	Bushire.	Quetta.	Jacobabad.	Murree.	Rawal- pindi.	Lahore.	Leh.	Mount Abu.	Deesa.
4th	+088	+031	+050	+051	+080	+095	+051	-010	-007
5th	-075	-051	+017	+019	+030	+018	+070	-027	-040
6th	-061	-050	+005	-026	-060	-046	+025	-020	+023
7th	-035	0	-037	+043	+086	+071	-035	+062	+036
8th	+080	-010	+057	+034	-024	+012	+061	+017	+025
9th	+006	-030	-092	-096	-142	-140	+026	-053	-052
10th	-052	-032	-071	-025	-056	-057	-079	-069	-053
11th	+011	+086	-056	-057	-032	-022	-026	-078	-094
12th	+023	+021	-011	-054	-038	-113	-067	-105	-045
13th	-128	-004	+005	-013	+044	+072	-092	+131	+132
14th	-090	+064	+104	+102	+082	+112	+112	+061	+031

The pressure changes in India, it will be seen, give no marked indications of the eastward transfer of an area of low pressure from Baluchistan into Sind and Rajputana. The larger barometric movements were almost simultaneous at Leh, Mount Abu and Quetta. They were most pronounced at Mount Abu, and were considerably larger at Leh than at Quetta. A consideration of these facts, and of the whole of the observations, appears to establish that, even if this depression and disturbance advanced eastwards across Persia and Afghanistan, it developed considerably in India. This development of the depression apparently occurred in Rajputana after a period of diminishing pressure over the whole Indian area lasting for three days. As will presently be seen, this inference is confirmed by the phenomena of the storm on the 12th and 13th.

Winds were very light and unsteady in the area of depression on the 11th. Southerly winds prevailed at the head of the Bay and easterly winds in the Gangetic plain. Hence the general fall of the barometer of the previous three days had initiated a gentle indraught from the head of the Bay into the Gangetic plain. Skies were overcast in the Punjab and the western districts of the North-Western Provinces and the larger portion of Bengal, and were more or less heavily clouded over the whole of North-Western India. The weather was slightly unsettled over the whole of Northern India and numerous thunder-storms had occurred during the preceding 24 hours in Bengal, Bihar, the North-Western Provinces, Central India, Rajputana, Sind and the Punjab.

The depression in North-Western India intensified slightly during the next 24 hours

and remained almost unchanged in position. The following observations define its position at 8 A.M. of the 12th :—

STATION.	PRESSURE.			WIND.		Amount of cloud, 8 A.M.
	8 A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.	Direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.	
Ajmere	29.757	—0.078	—0.229	S	4	8
Lahore	749	—113	—192	E	4	10
Montgomery	707	—149	?	NNE	10	8
Jacobabad	820	—011	—097	W	3	0
Deesa	754	—045	—199	SW	14	3

The centre of the depression was probably a little to the north of Bickaneer, and the amount of the depression at the centre did not exceed a quarter of an inch.

Skies at 8 A.M. were overcast in the Punjab and western districts of the North-Western Provinces and were heavily clouded in the Bengal and the Gangetic plain. There was moderate cloud in Rajputana, but skies were now clear in Sind.

A moderate and fairly well-marked cyclonic circulation obtained in the depression. The most important feature of the air movement on this day was undoubtedly the steady damp easterly winds which prevailed over the whole of the Gangetic plain. Weather was gloomy and unsettled, with frequent thunder-storms over the whole of Northern India, and general rain had been received during the previous 24 hours in Bengal, the North-Western Provinces, the Punjab, Rajputana, Sind and Central India. The largest amounts (in some cases exceeding 2 inches) were recorded in the East Punjab and Bengal.

The depression remained practically stationary in position during the day, but began to fill up. The following observations define its position and character at 8 A.M. of the 13th :—

STATION.	PRESSURE.			WIND.		Amount of cloud, 8 A.M.
	8 A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.	Direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.	
Deesa	29.886	+132	—061	WSW	9	0
Ajmere	893	+136	—084	SW	9	4
Sirsa	792	+078	—141	WSW	7	10
Lahore	821	+072	—117	E	5	10
Mooltan	820	+082	—121	Calm	2	0
Jacobabad	825	+005	—088	NE	5	0
Hyderabad	798	—038	—127	NW	10	0

The depression was now elliptical shaped, the longer axis running from Hyderabad to Sirsa and the centre was less clearly defined than on the previous day, but was probably near Bickaneer. The depression at the centre was now less than two-tenths of an inch.

Skies were overcast over the whole of Northern India from Bengal to the Punjab, but were clear or very lightly clouded over the Peninsula, and in Central India, Rajputana and Sind, strong easterly winds had prevailed during the previous 24 hours over the whole of the Gangetic plain, and rain (chiefly accompanying thunder-storms) had fallen more or less generally over the whole of Northern and Central India. Rainfall, varying from 2 to 3 inches in amount, had been received at many stations in Bengal, Bihar, Chota Nagpur and the North-Western Provinces, and showers in the Punjab and Rajputana.

The barometer rose rapidly in North-Western India during the day, and on the morning of the 14th high pressure conditions were established in Upper India, and the disturbance and depression of the previous 24 hours rapidly filled up. Skies had cleared very rapidly in the Punjab, the North-Western Provinces and Bihar, but were still heavily clouded in Bengal, in which there was a slight residual depression, the centre of which was near Dacca. Light showers had fallen in Bengal, the Punjab and western districts of the North-Western Provinces, but the amounts were generally small. Calms were reported by the great majority of stations in the Punjab and North-Western Provinces on this day and light irregular winds in Bengal. The residual depression passed eastward into Upper Burma and probably filled up on the 15th.

The preceding storm differed in many important points from the cold weather storms of the preceding months of January and February, more especially in the following:—

1st.—It was during the whole period of its existence in India a stationary, and not a moving depression.

2nd.—It formed in Rajputana during a period of general and continuous decrease of pressure, and may have been the development of a small and unimportant depression which apparently advanced across Central Persia three days previous to the appearance of the depression in North-Western India; but this appears on the whole to be very doubtful.

3rd.—Although it was a feeble storm, it gave rise to a more clearly defined cyclonic circulation than usual in the cold weather.

4th.—During its existence an unusually strong and steady influx of moist winds from the head of the Bay extended over the whole of Northern India from Bengal to the Punjab, which gave very disturbed weather and unusually heavy and general rain over the whole of that area for a period of three days.

5th.—The fact that it was stationary from the 11th to the 13th appears not only to be a strong proof that it did not enter India from Baluchistan, and was formed in India, but also that it was not generated in the upper easterly atmospheric current in which the cold weather storms are usually imbedded and carried across India. It was apparently a storm generated in North-Western India during a period of decreasing pressure which caused an unusual influx of moist winds from the head of the Bay up the Gangetic valley. These suppositions would evidently explain the distribution of the rainfall, the general character of the weather and the occurrence of numerous hail and thunder-storms.

Storms of this class, *viz.*, depressions during the cold weather months, initiated in

India itself and dependent mainly for their continuance upon an unusual influx of moist winds across Northern India, are undoubtedly of occasional occurrence. The barometric changes on the 14th were generally small, but re-established normal conditions of pressure. Skies cleared in Bengal and were free from cloud over nearly the whole of India. Pressure began to give way in North-Western India on the 15th, and the observations indicated that a depression was entering Sind from Baluchistan.

(II.) Depression and storm of the 16th and the 17th March 1891.—A depression passed eastward to the north of Bushire on the 12th and 13th, and it is probable that this disturbance advanced at the rate of about 400 miles per diem and entered Baluchistan on the 15th.

The following table gives the barometric changes at certain stations from the 12th to the 18th :—

Barometric changes during 24 hours preceding 8 A.M. of	Bushire.	Quetta.	Jacobabad.	Mount Abu.	Deesa.	Murree.	Lahore.	Leh.
12th . . .	+ '023	+ '021	+ '011	+ '105	+ '045	+ '054	+ '113	+ '067
13th . . .	+ '128	+ '004	+ '005	+ '131	+ '132	+ '013	+ '072	+ '092
14th . . .	+ '090	+ '064	+ '104	+ '061	+ '031	+ '102	+ '112	+ '112
15th . . .	+ '080	+ '019	+ '026	+ '048	+ '019	+ '032	+ '020	+ '062
16th . . .	+ '057	+ '026	+ '068	+ '010	+ '004	+ '011	+ '005	+ '001
17th . . .	+ '024	+ '014	+ '003	+ '033	+ '009	+ '061	+ '083	+ '067
18th . . .	+ '058	+ '143	+ '103	+ '073	+ '056	+ '064	+ '081	+ '003
19th . . .	+ '045	+ '006	+ '016	+ '003	+ '010	+ '026	+ '015	+ '081

The following observations show that the depression was entering Sind on the morning of the 16th :—

STATION.	PRESSURE.			WIND.		Amount of cloud, 8 A.M.
	8 A.M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.	Direction, 8 A.M.	Average velocity in miles per hour during previous 24 hours.	
Quetta . . .	...	+ '026	+ '060	Calm	1	4
Kurrachee . . .	29'910	+ '020	+ '021	WNW	10	5
Hyderabad . . .	'894	+ '021	+ '016	SW	6	10
Jacobabad . . .	'887	+ '068	+ '006	E	3	4

The depression was evidently not a large or important one. Skies were clear except in Sind and the Punjab, and westerly winds obtained in the Gangetic plain, and northerly winds in Central India and Central Provinces. Pressure increased during the day in North-Eastern India and diminished in North-Western India. The observations of the morning of the 17th show that the depression had been transferred about 400 miles in an

east-north-east direction and covered the South Punjab at 8 A.M. of that day. The following observations indicate its position and character at that hour:—

STATION.	PRESSURE.			WIND.		Amount of cloud, 8 A. M.
	8 A. M. Corrected to sea-level and constant gravity.	Change in preceding 24 hours.	Variation from normal of day.	Direction, 8 A. M.	Average velocity in miles per hour during previous 24 hours.	
Sirsa	29.819	—'119	—'098	SE	6	9
Lahore	'875	—'083	—'047	Calm	3	10
Montgomery	'831	—'137	?	N	7	3
Mooltan	'914	—'076	—'012	NE	1	10

Heavy rain had fallen in the North and North-West Punjab during the past 24 hours, and skies were generally overcast in the Punjab. They were clear in the Gangetic plain, down which westerly winds continued to blow.

The barometer rose rapidly during the day in the Punjab, as the depression moved eastward towards the hills. The depression disappeared before the morning of the 18th. Light showers had fallen chiefly in the north of the Punjab during the previous day. Skies cleared rapidly on the 18th, and on the morning of the 19th they were clear or lightly clouded over the whole of India.

Westerly winds continued in the Gangetic plain, so that the air motion in that area had been absolutely unaffected in direction by the passage of the small depression.

This small storm was evidently an example of the numerous class of cold weather disturbances which advanced across Baluchistan into India. It was probably the same disturbance which passed to the north of Bushire on the 12th.

If this be the case, it advanced eastwards at the rate of about 400 miles per diem, which is probably a little less than that of the easterly current which carries them across Northern India. The extent of area occasionally affected by these cold weather storms is further shown by the fact that the sky at Meshed in North-Eastern Persia, which was clear from the 10th to 13th, clouded over on the 13th, and was overcast until the 17th, on which day it again cleared, and fine clear weather prevailed until the 20th. This storm, as already been shown, affected Bushire. It contrasts strikingly with the previous storm, as the rainfall accompanying it was restricted to Baluchistan and the Punjab, and, during the existence, fine, clear, dry weather obtained in the Gangetic plain.

CHAPTER III.

The following table gives a statement of the most important features of the cold weather storms more or less fully described in the preceding pages.

It will be found useful for reference in the following chapter, discussing the more important features of these storms :—

1876-77.

Number of storm.	Date of storm.	Character of storm.	Where formed.	Track and rate of motion.	Period of existence in India.	Observed maximum amount of depression.	Distribution and character of rainfall accompanying storm.	Barometric movement over India during 48 hours previous to appearance of storm in Upper India.
1	1877 11th to 14th Jan.	Double disturbance.	Primary Second-ary. East Punjab.	Advanced eastwards at a daily rate of about 350 miles. Stationary .	Four days Nearly three days.	About a tenth of an inch. Four-tenths of an inch.	Heavy general rain in Northern India. Very heavy rain in the Punjab and snow in the hills.	
2	" 28th to 31st Jan.	Slight double disturbance.	Primary Second-ary. North Punjab.	Advanced eastwards at a rate of about 350 miles per diem. Stationary .	Four days ...	Slight . . Small . .	... Light general rain in the Punjab and snow in the hills.	
3	" 2nd to 5th Feb.	Slight double disturbance.	Primary . ? Second-ary. Punjab.	Advanced eastwards at a rate of about 350 miles per diem. Stationary .	Four days Two days.	Fifth of an inch Three-tenths of an inch.	Light showers in Northern India. Light general rain in the Punjab.	
4	" 5th to 8th Feb.	Large double disturbance.	Primary Second-ary. ... Primary	Advanced eastwards at an average rate of about 350 miles per diem. Stationary . Marched eastwards at an average rate of about 300 miles per diem.	Four days Two days Four days	Two-tenths of an inch. Three-tenths of an inch. Shallow .	Moderate general rain in Northern India. Moderate heavy rain in the Punjab. Light rain in the North-Western Provinces and Bihar.	
5	" 20th to 23rd Feb.	Slight double disturbance.	Primary Second-ary. Punjab .	Stationary .	Two days	Shallow .	Mod-erate rain in the Punjab.	

1877-78.

6	1877	23rd to 28th Nov.	Double disturbance.	Primary	?	Advanced eastwards across Northern India.	Six days	Shallow .	Light rain in the North-Western Provinces.	
				Secondary.	North Punjab.	...	Three days	Deepish depression about 4".	Heavy rain in the northern districts of the Punjab.	

1877-78—concluded.

Number of storm.	Date of storm.	Character of storm.	Where formed.	Track and rate of motion.	Period of existence in India.	Observed maximum amount of depression.	Distribution and character of rainfall accompanying storm.	Barometric movement over India during 48 hours previous to appearance of storm in Upper India.
7	1877 9th to 12th Dec.	Double disturbance.	Primary. Probably Baluchistan.	Advanced eastwards from Baluchistan across Northern India.	Four days	Shallow	Light rain in Bengal, Bihar and the North-Western Provinces.	
			Secondary. North-East Punjab.	Stationary	Two days	Deep depression, maximum about 4".	Heavy rain in the Punjab and snow in the hills.	
8	" 27th to 31st Dec.	Single disturbance.	?	Appeared on Sind frontier and marched eastwards at an average rate of about 350 miles per diem.	Four days	Shallow	Light to moderate general rain in Northern India.	
9	1878 23rd to 28th Jan.	Double disturbance.	Primary. North-West Frontier.	Advanced eastwards from Sind to Bengal at an average rate of 300 miles per diem.	Five days	One-tenth of an inch.	General light to moderate rain to the North-Western Provinces, Bihar and Bengal.	
			Secondary. ...	Stationary	Three days	Four-tenths of an inch.	Heavy rain in the Punjab.	
10	" 9th to 12th Feb.	Single disturbance with slight tendency to formation of a secondary in the Punjab.	North Punjab, Probably North-West Frontier.	Advanced eastwards at a rate of about 400 miles per diem.	Four days	Two-tenths of an inch.	Showers over Northern India, and heavy snow in the Kashmir Himalayas.	
			Primary. ...	Appeared on North-west Frontier and advanced eastwards at a rate of about 400 miles per diem.	Four days	One-sixth of an inch.	Light local showers of little importance in North-Western Provinces.	
11	" 24th to 28th Feb.	Double disturbance.	Secondary. North Punjab.	Stationary	Three days	Five-tenths of an inch.	Heavy rain in the Punjab, and snow in the hills, especially in Kashmir.	

1878-79.

12	1879	19th to 22nd Feb.	Small stationary storm.	...	Rajputana	Stationary	Three days	Never exceeded a tenth of an inch.	Confined to Rajputana, Central India and adjacent district of the Central Provinces and moderate in amount.	Barometer falling on the 18th over the whole of North-Western and Central India.
13	"	10th to 14th Mar.	Small storm consisting of a primary and a secondary depression.	Primary.	Existence first shown in Baluchistan.	Advanced from Baluchistan through Upper Sind into Rajputana, where it filled up.	Three days	Small, slightly exceeding a tenth of an inch.	Showers in Baluchistan and Sind.	Barometric movements small and irregular on previous two days.
				Secondary.	North Punjab.	Stationary	Four days	Greatest at Peshawar on 13th at 10 A.M., when it was "20".	General and moderate heavy rainfall in the Punjab and western districts of the North-Western Provinces and moderately heavy snow on the hills.	

1879-80.

Number of storm.	Date of storm.	Character of storm.	Where formed.	Track and rate of motion.	Period of existence in India.	Observed maximum amount of depression.	Distribution and character of rainfall accompanying storm.	Barometric movement over India during 48 hours previous to appearance of storm in Upper India.	
14	1879 24th to 26th December.	Moderate single depression.	...	Existence first shown in Baluchistan and Upper Sind.	Marched eastwards from Upper Sind to the South-East Punjab.	Three days	28½" at Mooltan on the 25th.	Showers in the Punjab and hills.	Barometer falling generally, most so in North-West India and Sind, on the 22nd. It fell throughout the whole country on the 23rd.
15	" 26th to 28th December.	Moderate single depression.	...	...	Marched eastwards from Upper Sind.	Three days	27" at Sirsa.	Light rain in Rajputana, Punjab and western districts of the North-Western Provinces.	Barometer falling generally on the 24th and 25th, but rising on the 26th.
16	1880 17th to 20th January.	Small depression with slight tendency to development of a secondary depression.	...	Advanced from Baluchistan; probably formed in that area.	Advanced eastwards from Baluchistan through Upper Sind and Central Rajputana and filled up on approaching the North-Western Provinces Himalayas.	Three days	About 28" at Jacobabad on 17th.	Rain fell chiefly in the Punjab, and was moderate in amount.	Barometer falling over Upper India on the 15th, and the whole of India on 16th, or for two days antecedent to appearance of storm in Baluchistan.
17	" 28th to 30th February.	Small and shallow depression.	...	Advanced from Baluchistan.	Advanced eastwards through Upper Sind and North Rajputana to neighbourhood of hills in South-East Punjab.	Upwards of three days.	Greatest at Jacobabad at 10 A.M. of 8th, when it was 134".	Light to moderate rain in the Punjab and the North-Western Provinces.	Barometric changes irregular on the 6th. Barometer falling in the north-west and west of India on the 7th and rising in North-East India.
18	" 15th to 18th February.	Shallow depression, which gave rise to a small secondary depression in the East Punjab.	Primary.	Probably in Central India and South Rajputana.	Marched almost due eastwards along the parallel of 24° N. into East Bengal or Upper Burma.	Four days	Greatest at Jubbulpore, where it was 252".	Thunder showers in Central Provinces, Bihar and Bengal.	Barometer falling generally on the 15th and 16th prior to formation of depression.
			Secondary	Formed in the South-East Punjab.	Almost stationary.	Two days	Deepest at Rawalpindi on 17th, where depression was 40" in amount.	Heavy rain in South-East Punjab and hills and moderate rain in the North-Western Provinces and Oudh.	

1880-81.

19	1880 14th to 16th Dec.	Feeble double depression.	Primary.	West Rajputana.	Almost stationary.	Three days.	Greatest depression was 11" at Sirsa on the 15th.	Moderate rain in the Punjab and North-Western Provinces.	Pressure increased generally on the 12th and 13th.
			Secondary (very feeble).	North Punjab.	Stationary.	Two days.	17" at Murree on the 16th.		•

1880-81 - concluded.

Number of storm.	Date of storm.	Character of storm.	Where formed.	Track and rate of motion.	Period of existence in India.	Observed maximum amount of depression.	Distribution and character of rainfall accompanying storm.	Barometric movement over India during 48 hours previous to appearance of storm in Upper India.
20	1881 2nd to 6th March.	Double storm, of which the secondary depression formed in the North Punjab.	Primary. Baluchistan.	It advanced on an easterly track through Sind, Rajputana, Central India and Chota Nagpur to Upper Burma at an average rate of about 450 miles per diem.	At least five days.	'15" at Hazaribagh on the 4th.	Light rain to Sind, Rajputana, Bihar, Chota Nagpur and Assam.	General rapid fall of the barometer occurred on the 28th February and 1st March.
			Secondary North Punjab.	Almost stationary.	Two days.	'294" at Peshawar on the 3rd.	Moderate to heavy rain in the Punjab, Himalayas, the Punjab, and the western districts of the North-Western Provinces.	

1881-82.

21	1882 10th to 13th Jan.	Single disturbance of slight intensity.	.....	Probably entered Sind from Baluchistan on the 10th.	Marched rapidly eastwards across Rajputana to the North-West Provinces Himalayas.	Three days	One-tenth of an inch at Jeypore on the 11th.	Moderate rain in the East Punjab, Rajputana and western districts of the North-Western Provinces.	Barometer risen on the 8th, but fallen generally on the 9th and 10th in India.
22	" 30th Jan. to 2nd Feb.	Single disturbance of very slight intensity.	.....	Originated in Central India.	Marched eastwards at rate of 300 miles per diem	Four days	Never exceeded one-tenth of an inch.	Light showers in the Punjab, Rajputana, western districts of the North-Western Provinces and Assam.	Barometer fallen over the whole of India on the 27th, risen briskly on the 28th, and fallen slightly to moderately on the 29th.
23	" 10th to 13th Feb.	Double disturbance.	Primary	Formed in North-Western India	Travelled from Sind to Bengal in an E. by S. track at an average rate of 350 miles per diem	Four days	A sixth of an inch due to the primary depression.	Showers in the North-Western Provinces, Bihar, Bengal and Assam.	General fall of the barometer on the 7th, 8th and 9th over the whole Indian area.
			Secondary	Formed in the North Punjab.	Stationary.	Two days	'445" at Peshawar on the 11th.	Moderate rain in the Punjab and western districts of the North-Western Provinces.	
24	" 13th to 16th Feb.	Single disturbance of slight intensity.	.....	Formed in Rajputana.	Marched eastwards.	Three days	'147" at Ajmere.	Light showers in Upper India.	

1882-83.

Number of storm.	Date of storm.	Character of storm.	Where formed.	Track and rate of motion.	Period of existence in India.	Observed maximum amount of depression.	Distribution and character of rainfall accompanying storm.	Barometric movement over India during 48 hours previous to appearance of storm in Upper India.
25	1883 23rd to 29th Jan.	Double storm, of which the primary depression was feeble.	Primary Passed into North-Western India from Baluchistan. Secondary. In North Punjab	It advanced in an E. S. E. direction from Upper Burma at an average rate of motion of 350 miles per diem. Stationary.	Five days. Three days from 24th to 26th.	Greatest depression was 25" at Jacobabad on the morning of 24th. Greatest depression was observed at Lahore on the 25th amounting to 42"	Slight to moderate rain in Rajputana, Central India, Bihar and Bengal. Heavy rain in the Punjab and North-Western Provinces.	Changes irregular on the 21st. Barometer began to fall generally in Northern India on the morning of the 22nd.

1883-84.

26.	1883 8th to 13th Nov.	Moderate single depression and almost stationary during existence.	...	Formed in South Punjab and North Rajputana.	Stationary.	Five days.	23" at Multan on the 10th.	Heavy rain in North Punjab and rain and snow in hill districts.	Barometer fell generally over Northern and Central India on the 6th. Changes irregular on the 7th.
27	1884 25th. to 27th Jan.	Small single depression.	...	Advanced from Baluchistan, where it probably formed.	Advanced in an easterly direction from Quetta to Sirsa, and thence to foot of hills in N.W. Provinces, where it filled up. Rate of motion about 250 miles per diem.	Three days.	14" at Multan on the 26th.	Moderately heavy rain in North Punjab and moderate rain in South Punjab.	Barometer rose generally on 23rd and 24th.
28	" 1st to 5th Feb.	Double depression, consisting of a shallow primary depression and of a moderate but very short-lived secondary depression.	Primary depression. Secondary depression.	Entered Sind from Baluchistan, and probably formed in that area. Formed in the North Punjab on the 3rd, and filled up on the morning of the 5th.	Advanced along an almost due east course from Jacobabad to Bareilly, breaking up in Rohilkhand. Stationary.	Four days. Two days.	13" at Agra on the 4th. Deepest at Feshawar and Dera Ghazi Khan on 4th, 22."	Light showers in Sind, North and West-Punjab and western districts of the N.W. Provinces. Moderate rain in North Punjab and heavy snow in hill districts.	Barometric movement is irregular on the 30th, but pressure fell generally on the 31st.

1884-85.

Number of storm.	Date of storm.	Character of storm.	Where formed.	Track and rate of motion.	Period of existence in India.	Observed maximum amount of depression.	Distribution and character of rainfall accompanying storm.	Barometric movement over India during 48 hours previous to appearance of storm in Upper India.	
29	1885 5th to 10th Jan.	Double disturbance, consisting of a shallow primary depression and of a short-lived deep secondary depression.	Primary .	Probably advanced from Persia through Baluchistan.	It advanced in an E. by S. track from Central Baluchistan into Bihar at an average rate of about 320 miles per diem.	Five days	"22" at Jacobabad on the 7th.	Gave general rain to the Punjab and light rain to Sind, Rajputana, the North-Western Provinces and Central India.	Barometer falling generally on 4th and 5th in India.
	"		Secondary	Formed in the North Punjab on the 6th and filled up on the 9th.	...	Three days.	"32" at Mooltan on the 8th.	Gave heavy rain to the Punjab and western districts of the North-Western Provinces and excessive snow in Baluchistan, Afghanistan and North-West Himalayas.	
30	" 27th to 30th Jan.	Consisted of a very shallow primary depression.	...	Advanced into Sind from Baluchistan, where it probably formed.	Marched by an E. by S. track from Central Baluchistan into Upper Burma. Average rate 500 miles per diem.	Four days	"18" at Jeypore on the 28th.	Gave moderate rain to the Punjab, North-Western Provinces, and light rain to Rajputana, Sind, Bihar, Bengal, Assam and Upper Burma.	Pressure decreased over India on the 25th, but increased generally on the 26th and again decreased on the 27th.
31	" 2nd to 7th Feb.	Consisted of a shallow primary depression which advanced across Northern India and of a feeble shallow secondary stationary depression in the Punjab.	Primary .	Probably formed in Sind and West Rajputana or in East Baluchistan.	Advanced E. by S. from Upper Sind to Upper Burma. Average rate of motion 340 miles per diem.	Five days	...	Light to moderate rain, Punjab, Bihar, Bengal and Assam.	Pressure decreased on the 31st in the north and west of India, but increased elsewhere. Changes irregular on the 1st and 2nd, but generally upward.
			Secondary	Punjab .	Stationary .	One day .			

1885-86.

32	1886 17th to the 20th Jan.	Double disturbance, consisting of a feeble primary depression and of a deep secondary depression in the North Punjab.	Primary .	Probably formed in Sind or Baluchistan.	Advanced from Sind into Central India, where it apparently filled up.	Four days.	"24" at Hyderabad Sind on the 19th.	Heavy rain in the Punjab and moderate rain in the North-Western Provinces. Practically none in Rajputana, Central India and Bihar.	Pressure gave way throughout the country on the 15th, but increased on the 16th, except in North-West India.
			Secondary.	Formed in the North Punjab on the 18th and filled up on the 20th.	Stationary .	Three days.	"37.1" at Dera Ismail Khan and "36" at Peshawar on the 19th.		

1885-86--concluded.

Number of storm.	Date of storm.	Character of storm.	Where formed.	Track and rate of motion.	Period of existence in India.	Observed maximum amount of depression.	Distribution and character of rainfall accompanying storm.	Barometric movement over India during 48 hours previous to appearance of storm in Upper India
33	1886 14th to 18th Feb.	Double disturbance, consisting of a feeble primary depression and a very deep secondary depression.	Primary. Formed in West Rajputana, but probably the continuation of a very slight disturbance in Baluchistan on 13th.	Advanced from West Rajputana to Bengal.	Five days.	"14" at Jhansi on the 16th.	Very light showers in Northern India, and heavy snow on the hills.	Pressure increased on the 12th, but decreased moderately to rapidly throughout the whole country on the 13th and 14th.
			Secondary. Formed in the North Punjab on the 15th.	Stationary	Two days.	"44" at Peshawar on the 16th.		
34	" 6th to 12th Mar.	Feeble single depression.	... Probably formed in Baluchistan.	Advanced from Baluchistan across Northern India into Upper Burma with an average velocity of about 300 miles per diem.	Six days.	"11" on the 7th at Dacca.	General and moderately heavy rain over the whole of Northern India and light rain in Rajputana, Central India and the Central Provinces.	Pressure changes generally upward on the 4th; barometer falling generally on the 5th and 6th.

1886-87.

35	1887 10th to 16th Jan.	A double disturbance, consisting of a shallow and diffused primary disturbance and a shallow secondary disturbance or depression in the Punjab.	Primary. Rajputana and Central India.	Probably almost stationary.	Three days.	"14" at Jyepore on the 13th.	Light to moderate rain in Northern and Central India and the Central Provinces.	Barometric changes variable on the 8th and 9th, or for two days previous to the appearance of storm.
			Secondary. Formed in the North-East Punjab on the 12th.	Transferred eastwards along the Himalayas.	Four days.	"46" at Peshawar, "20" at Murree, on the 14th.	Moderate snow in the hills.	
36	" 17th to 23rd Jan.	A double disturbance, consisting of a deepish primary and of a moderately deep secondary depression in the North Punjab.	Primary. Rajputana and Central India.	Advanced eastwards into Burma.	Six days.	"29" at Allahabad on the 20th.	General heavy rain in Bengal, Bihar, Chota Nagpur and the North-Western Provinces and light to moderate rain in Assam and Rajputana. Moderate rain in North Punjab. Moderate to heavy snow on the Punjab hills and Afghan hills and heavy snow in the East Himalayas.	Barometer rises very rapidly in the north-west and falls in the east of India on the 15th. On the morning of the 16th it had fallen in the north and west and risen in the east of India.
			Secondary. North Punjab.	Stationary	...	"31" at Peshawar and Dera Ismail Khan on the 20th.		

1887-88.

Number of storm.	Date of storm.	Character of storm.	Where formed.	Track and rate of motion.	Period of existence in India.	Observed maximum amount of depression.	Distribution and character of rainfall accompanying storm.	Barometric movement over India during 48 hours previous to appearance of storm in Upper India.	
37	1888 11th to 13th Jan.	A shallow depression.	...	Probably Persia.	Passed over Bushire on the 8th and 9th, over Quetta and Peshin on the 10th and 11th, and over South-West Rajputana on the 12th, where it filled up. Average rate between 300 and 400 miles per diem.	Three days	Nearly a tenth of an inch.	Moderately heavy snow in Afghanistan and Baluchistan and showers in the North Punjab.	General fall of the barometer on the 9th and 10th. Fall brisk in the Punjab and Sind.
38	" 20th to 25th Jan.	Consisted of a shallow primary depression and of a shallow secondary depression.	Primary.	Crossed from Baluchistan.	The centre was to the north-east of Hyderabad on the 20th, in West Rajputana on the 22nd, in Bundelkhand on the 23rd, and in North Orissa on the 24th. It travelled with an average velocity of 360 miles.	Four days	Two-tenths of an inch.	Light to moderate rain in Central India, Bengal and Bihar.	Barometer risen over the whole of India on the 18th. A brisk fall of the barometer in the Punjab on the 12th. Pressure increased elsewhere.
			Secondary.	North Punjab.	Stationary in North Punjab on the 21st to 22nd.	Two days	About two-tenths of an inch.	Moderately heavy snow on the Punjab Himalayas and rain in the North Punjab and the North-Western Provinces.	
39	" 24th to 29th Jan.	A double disturbance, consisting of a shallow primary and a deepish secondary depression.	Primary.	Probably passed from Persia into Baluchistan.	Was to the north of Bushire on the 21st, in Baluchistan on the 24th, in South-West Rajputana on the 25th, in the central districts of the Central Provinces on the morning of the 26th, in Orissa on the 27th, and to the south of Akyab on the 29th. Average rate of motion about 365 miles per diem.	Five days	A sixth of an inch on the 26th.	Light to moderate rain or snow to Baluchistan, and light rain to Sind, Rajputana, Central India, the Central Provinces, Orissa, Bengal, Assam and Burma.	A very rapid fall of the barometer on the 22nd, followed by a general rise of pressure on the 23rd, most rapid in the Punjab and Rajputana.
			Secondary.	Formed in the North Punjab on the 25th.	Stationary.	Two days	"23" at Rawalpindi on the 26th.	Moderate and general rain to the Punjab and the N.-W. Provinces.	...

1888-89.

Number of storm.	Date of storm.	Character of storm.	Where formed.	Track and rate of motion.	Period of existence in India.	Observed maximum amount of depression.	Distribution and character of rainfall accompanying storm.	Barometric movement over India during 48 hours previous to appearance of storm in Upper India.
40.	1889 3rd to 5th Jan.	A shallow primary depression.	...	Appeared in Upper Sind and the South-West Punjab, and probably originated there.	Travelled eastwards to the Himalayas.	Three days	Nearly two-tenths of an inch.	No rain in plains of India. Pressure was rising generally on the 1st and 2nd.
41.	" 9th to 12th Jan.	A very shallow primary depression.	...	In the Punjab.	Moved eastwards along the base of the Himalayas to Assam.	Four days	...	It gave snow to the higher elevations of the Himalayas. Pressure increased throughout the whole of India on the 7th, but decreased on the 8th; fall brisk in the north-west.
42.	" 28th Jan. to 2nd Feb.	A large disturbance, consisting of a shallow primary depression and of a deep secondary depression.	Primary.	Passed from Baluchistan on the 28th.	The central depression was in West Rajputana on the morning of the 29th, in the northern districts of the Central Provinces on the 30th, in Long. 86° E. on the 31st, in Long. 92° or 93° E. on the 1st, and in Long. 97° or 98° E. on the 2nd. Average rate of motion about 400 miles per diem.	Five days	Less than a seventh of an inch.	Moderate rain to the Punjab, the North-Western Provinces, Rajputana, Central India, Bengal and Assam. Pressure was rising generally on the 24th, 25th, and 26th, and began to give way generally on the 27th.
43.	" 5th to 7th Feb.	A shallow depression.	Secondary	The North Punjab on the 29th and filled up on the 31st.	Travelled very slowly south-eastward along the Punjab Himalayas.	Three days	About four-tenths of an inch.	Very heavy snow to the Punjab Himalayas and heavy rain to the Punjab and western districts of the North-Western Provinces. Pressure was rising over all the country on the 3rd, the rise being most rapid in North-Western India.

1888-89—concluded.

Number of storm.	Date of storm.	Character of storm.	Where formed.	Track and rate of motion.	Period of existence in India.	Observed maximum amount of depression.	Distribution and character of rainfall accompanying storm.	Barometric movement over India during 48 hours previous to appearance of storm in Upper India.
44	1889 15th to 21st Feb.	Consisted of a shallow primary depression and of a shallow short-lived secondary depression. The combined depressions gave rise to an elongated trough of low pressure for about 48 hours.	Probably in Baluchistan.	Marched in an easterly direction from Sind to Upper Burma at an average rate of 300 miles per diem.	Six days	About a tenth of an inch.	Very general rain to the whole of Northern and Central India between the 45th and 20th.	The barometer was rising all over India on the 13th and 14th.
45	" 20th to 25th Feb.	A very deep depression.	Most probably formed in Sind.	Travelled northwards on the afternoon of the 22nd, centre on the morning of the 23rd being between Jacobabad and Mooltan, and on the 24th near Dera Ismail Khan. It was a remarkably slow-moving storm, and its average rate of motion was only about six miles per hour.	Five days	Three-tenths of an inch.	Very heavy rain to the Punjab and heavy snow on the Punjab Himalayas and Afghan Mountains.	Pressure was decreasing generally on the 17th, 18th and 19th.

1889-90.

			Primary	Apparent-ly advanced from Persia.	Advanced in an easterly direction from Baluchistan and Upper Sind to East Bengal and Upper Burma at an average rate of nearly 400 miles per diem.	Five days	"24" in Bengal	Moderate and general rain to Bengal.	Barometer fallen rapidly throughout the whole of India on the 16th; fall rapid in Northern India.
46	1890 20th to 25th Jan.	Consisted of a shallow primary depression and of a small shallow secondary depression.	Secondary	Formed in the North-East Punjab on the 21st.	Almost stationary.	Three days	"2" in North Punjab.	Moderate rain in the Punjab and hills.	
47	" 5th to 7th Feb.	Very shallow primary depression.		Formed in Sind.	Advanced eastwards to neighbourhood of hills in North-West Provinces.	Three days	"13" at Jacobabad and "31" at Agra.	Snow in the Punjab hills and Baluchistan.	Barometer fallen over India on the 3rd and 4th.
48	" 14th to 17th Feb.	Primary depression.		Formed in Baluchistan and Sind.	Advanced eastwards from Sind to Bengal.	Four days	"30" at Jacobabad and "31" at Agra.	Snow in the Punjab hills and Baluchistan and light to moderate rain in the Punjab.	Barometer fallen all over India on the 12th and 13th.

1890-91.

Number of storm.	Date of storm.	Character of storm.	Where formed.	Track and rate of motion.	Period of existence in India.	Observed maximum amount of depression.	Distribution and character of rainfall accompanying storm.	Barometric movement over India during 24 hours previous to appearance of storm in Upper India.	
49	1890 25th to 28th December.	A double disturbance, consisting of a shallow primary and shallow secondary depression.	Primary	Advanced from Persia.	Marched in an easterly direction from Upper Sind to Bengal.	Four days	A seventh of an inch.	Slight rain in the Punjab.	A rapid fall of barometer in the Punjab on the 23rd, succeeded by a brisk rise over whole of India.
			Secondary.	Formed in Central Punjab on the 24th.	Nearly stationary.	Three days	Less than a tenth of an inch.	Snow in hills and rain in the Punjab.	
50	" 7th to 10th January.	Shallow primary and of a shallow secondary depression in the Punjab.	Primary	Formed in North-West Provinces.	Advanced rapidly eastwards to Bihar.	Four days	21" at Benares on 9th.	...	A brisk rise of pressure in the Punjab on the 5th, followed by a general fall over India on the 6th.
			Secondary.	Formed in South-east Punjab on the 8th.	Nearly stationary.	Three days	21" at Sirsa and Ludhiana.		
51	1891 15th to 17th January.	A double disturbance, consisting of a shallow primary and of a deep secondary depression in the Punjab.	Primary	Advanced from Baluchistan or East Persia.	Marched eastwards across the South Punjab.	Three days	Small.	Rain in Upper India. Heavy fall of snow in the Western Himalayas.	Moderate fall of barometer over India, followed by a brisk rise in the Indus valley on the 14th.
			Secondary.	Formed on the 15th in the Central Punjab.	...	Do.	32" at Montgomery on 4th.	Rain in the Punjab plains, Rajputana and Sind, and snow on hills.	
52	" 1st to 5th February.	A double disturbance, consisting of a shallow primary and of a deep but shortened secondary depression.	Primary	Entered Sind from Baluchistan on the 31st January.	Marched in an easterly direction from Sind to Assam at an average rate of 400 miles per day.	Five days	29" at Ajmere on the 2nd.	...	Slight to brisk fall of the barometer over the Indus valley on the 30th and the whole of Upper India on the 31st.
			Secondary.	Formed in the North Punjab.	Stationary.	Two days	35" at Dera Ismail Khan on the 2nd.	Heavy rain in the Punjab plains, and heavy snow on the adjacent hills.	
53	" 20th to 22nd February.	A deep depression in the Central Punjab.	Primary	Probably formed in the Punjab.	Advanced slowly eastwards to the South-East Punjab.	Two days	34" at Multan on the 20th.	Rain in the plains and snow on the hills.	Moderate fall of barometer in Northern India on the 18th and a rapid fall of barometer over whole of India on the 19th.

Number of storm.	Date of storm.		Character of storm.	Where formed.	Track and rate of motion.	Period of existence in India.	Observed maximum amount of depression.	Distribution and character of rainfall accompanying storm.	Barometric movement over India during 48 hours previous to appearance of storm in Upper India.	
54	1891	11th to 15th Mar.	Feeble depression.		Most probably in Rajputana during a period of decreasing pressure.	Almost stationary.	Four days	23" at Ajmere on the 12th.	General rain all over Northern and Central India. It was heavy in Bihar, Chota Nagpur, Bengal and Assam.	Pressure diminishing generally on the 9th and 10th.
55	"	15th to 17th Mar.		Persia	It passed from Persia into Baluchistan on the 15th and thence into Sind on the 16th. It marched through Rajputana and the South-East Punjab with an average velocity of 400 miles per diem to the Punjab hills, where it broke up on the 18th.	Three days.	Nearly a tenth of an inch.	Heavy rain in the North and North-West Punjab.	Rises briskly to rapidly on the 13th and 14th.	

CHAPTER IV.

Discussion of the chief features of the cold weather storms of 1876-91.

In the preceding chapters is given a full statement and description of all the more important cold weather storms of the sixteen years 1876-91. The period is long enough to enable not merely the more characteristic features of the storms to be fully inferred but also the more important and conspicuous facts with respect to the tracks and distribution of these storms. The account given of the storms is much fuller than was originally intended, but it was considered that a fairly complete account would be more likely to lead to a comparison by European Meteorologists between these storms and the cyclonic storms of the temperate zone which they appear to resemble in their more important features.

The paper is intended to be chiefly descriptive and introductory to a more complete analysis of these storms when data have been collected. The first step towards the working out the theory of any important class of cyclonic storms is to ascertain fully all their more important and characteristic features. When this has been done it may be possible to work out as a hydro-dynamical problem the particular case of air motion on the large scale which will agree in all its major features with the actual motion of the class of storms under consideration. There are various points in connection with these cold weather storms in which enquiry is necessary, and observatories have been recently established on the North-West Frontier and in Baluchistan, Afghanistan, and Persia with a view to obtain data which will enable some at least of these features to be satisfactorily determined.

Various theories of cyclone generation have been proposed, but none has as yet obtained general acceptance. It is not necessary in the present paper to enumerate the various theories, as the chief object is to furnish data of an important and interesting class of cyclonic storms in India which appear to correspond far more closely with the storms of the United States and Europe than with the cyclones and cyclonic storms of the rains in the tropics, to which attention has been hitherto chiefly directed in India.

The information on many points is confessedly imperfect, and it appears to be desirable not to formulate a complete theory for these storms until further material has been collected on doubtful or disputed points.

It however appears to be probable that cyclonic storms may originate under various combinations of circumstances, and if such be the case any attempt to formulate a theory for all will necessarily fail to explain many important features of a special class. It appears hence to be desirable to differentiate between various classes of storms and to study the phenomena of each class separately.

It may be premised that storms in India may be arranged under the following divisions :—

- (1) Cyclonic storms of the south-west monsoon.
- (2) Cyclonic storms of the cold weather or north-east monsoon.
- (3) Storms of the hot weather, including tornadoes, nor'westers, thunderstorms,

hailstorms, duststorms, etc. They are usually of very small extent and rarely last more than a few hours.

The most prominent features of the cyclonic storms of the south-west monsoon are—

- 1st.—They form generally over the Indian Sea area, and in the great majority of cases in the Bay of Bengal.
- 2nd.—Their direction of advance ranges between west and north-east, and their mean direction is approximately west-north-west.
- 3rd.—The barometric depression in the storm area is frequently very large in amount and the winds at the sea-level of hurricane force.
- 4th.—They usually give heavy to excessive rain to the districts over which they pass, total falls of 15 to 20 inches being by no means unusual.
- 5th.—The temperature changes accompanying these storms are always small, and in the land area are entirely due to the rainfall, and hence the reduction of temperature which accompanies them depends chiefly upon the conditions prevailing previous to the storm.

The more characteristic features of the storms of the north-east monsoon or cold weather period are :—

- 1st.—They either form in the land area of North-Western India or advance from the plateau or mountain areas of Persia, Baluchistan and Afghanistan.
- 2nd.—Their direction of advance ranges between east and east-south-east and is very uniform.
- 3rd.—A large proportion of the storms give rise to subsidiary depressions in the Punjab with very marked cyclonic features.
- 4th.—The barometric depression in the primary disturbances is always small in amount, and the rainfall due to these storms in the plains of Northern India is usually moderate in amount, rarely exceeding three or four inches.
- 5th.—The temperature and hygrometric changes accompanying these storms are usually very marked. Every storm of importance is preceded in its advance across India by a warm wave and followed by a cool and dry wave.

The two classes of cyclonic storms hence differ widely in all their more important features. Hence the necessity for the division of storms in India adopted above.

The preceding remarks have given reasons for regarding the cyclonic storms of the cold weather in Northern India as belonging to a special class, and as differing in many of their more characteristic features from the cyclonic storms of the rains.

Before commencing the discussion of the more important features of these storms, a brief statement of their chief features appears to be desirable.

The disturbances under discussion form the chief feature of the cold weather in Northern India. The first indication of a disturbance of this class is usually a local fall of the barometer in Baluchistan, Sind, Rajputana or the West Punjab, and is followed by the appearance or formation of a shallow depression on the North-West Frontier (or in Sind, Kathiawar, Guzerat or Rajputana.) This depression usually drifts across Northern India in an easterly direction (generally with a slight southing), and either fills up in North Eastern India or passes into Burma. There is usually a considerable increase of temperature in

front of the advancing depression, and hence a wave of high or excess temperature appears to advance across Northern India in front of the depression. These depressions usually give light to moderate rain in Northern India, chiefly to the east and north of their track, or in the eastern and northern quadrants of the depressions.

Little or no rain falls in the central area, and in the majority of storms practically none in the south. The effects of these storms are almost restricted to Northern India north of the Satpuras, the changes of temperature etc. in the Deccan being usually small in amount.

In the majority of cases the appearance of these depressions in Sind and Rajputana is followed by the formation of deeper and smaller depressions in the North and Central Punjab. These depressions are usually almost stationary and fill up even more rapidly than they form, when the previously existing shallow depressions are entering Chota Nagpur or Bengal, and the barometric movements in the Punjab due to these storms are occasionally very large and rapid.

These deep depressions in the Punjab are evidently related to the contemporaneous shallow depressions crossing Northern India as they form and disappear at well-defined stages of the passage of the shallow depressions across Northern India, and apparently depend for their formation upon actions connected with the advance of these storms. They are hence subsidiary, and are therefore termed in this paper subsidiaries or secondaries to the former which are considered as the primary depressions.

The subsidiary depressions in the Punjab differ very considerably in extent and intensity, but they invariably give rise to more or less heavy snowfall in the Western Himalayas, and the Afghan Mountains, and moderate rain in the North and East Punjab.

The heaviest and most extensive snowfalls in the hill districts of Upper India and the most general rain during the cold weather season in the plains of Northern India usually occur during the existence of these secondaries. It is hence evident that they play an important part in the distribution of the cold weather precipitation, and from this point of view might be regarded as more important than the primary storms to which they are related and probably owe their existence.

The following table gives the number of cold weather storms in each year in the period 1876-91, enumerated in the preceding statement, and also shows how many of these storms gave rise to subsidiary depressions:—

YEAR.	Number of cold weather storms.	Number of primary storms which were accompanied with secondary disturbance.	Number of storms which did not give rise to a secondary depression.
1876-77	5	5	0
1877-78	6	4	2
1878-79	2	1	1
1879-80	5	1	4
1880-81	2	2	0

YEAR.	Number of cold weather storms.	Number of primary storms which were accom- panied with secondary disturbance.	Number of storm. which did not give rise to a secondary depression.
1881-82	4	1	3
1882-83	1	1	0
1883-84	3	1	2
1884-85	3	2	1
1885-86	3	2	1
1886-87	2	2	0
1887-88	3	2	1
1888-89	6	1	5
1889-90	3	1	2
1890-91	7	4	3
Total 1876-91	55	30	25

The preceding data show that out of a total of 55 primary storms 30 gave rise to or were accompanied by secondary storms or depressions in Upper India. In several of the remaining storms, there was a slight tendency to the formation of secondary depressions, but they did not pass beyond the initial stage.

There is hence a very strongly marked tendency for the primary depressions of the cold weather in Northern India to give rise to secondary depressions in the Punjab.

The secondaries form when the primary depressions are passing through Sind and West Rajputana. They are most intense when the primaries are in East Rajputana and Central India. They fill up when the primary storms are passing into Baghelkhand, Chota Nagpur and the north-eastern districts of the Central Provinces. They are hence definitely related to the primary depressions, forming and disappearing during a well-defined stage of the advance of the primaries. It is hence almost certain that their formation is the result of special actions set up in the Punjab by the primary disturbances.

The primary depressions, as a rule, appear in North-Western India during periods of general decrease of pressure over the Indian monsoon area. In a paper I prepared some years ago, but which has not been published, I endeavoured to show that in addition to the uniformities of the diurnal and annual oscillations of pressure, there are oscillatory movements or changes of intermediate periods in the Indian monsoon region, one of the most important of which appears to be an oscillation the period of which in the cold weather season is approximately five days.

The following table gives a statement of the mean barometric changes in the Indian land area during the months of November and December 1892, months which were

characterised by even more uniformly fine and clear weather than usual, more especially in Northern and Central India and the Deccan.

MONTH.	Date.	Mean barometric change over India during 24 hours preceding 3 A.M. of date.	MONTH.	Date.	Mean barometric change over India during 24 hours preceding 3 A.M. of date.
November 1892	1	—'019	December 1892	1	+ '045
	2	+ '004		2	+ '009
	3	+ '064		3	+ '031
	4	+ '081		4	—'011
	5	+ '025		5	—'044
	6	—'034		6	—'024
	7	—'020		7	+ '052
	8	—'004		8	0
	9	—'008		9	—'019
	10	+ '064		10	—'028
	11	+ '064		11	+ '037
	12	+ '007		12	+ '038
	13	—'062		13	—'003
	14	+ '003		14	—'043
	15	+ '043		15	+ '027
	16	—'008		16	+ '035
	17	—'019		17	+ '008
	18	—'024		18	—'033
	19	+ '004		19	—'027
	20	—'011		20	+ '043
	21	—'032		21	+ '026
	22	—'029		22	—'030
	23	—'001		23	—'002
	24	+ '089		24	—'017
	25	+ '008		25	+ '007
	26	—'001		26	—'022
	27	—'015		27	+ '002
	28	+ '028		28	+ '042
	29	+ '012		29	—'044
	30	—'016		30	—'012
				31	+ '054

A brief inspection at the preceding table shows clearly the regularity of the oscillatory changes of the pressure in this period of two months of fine weather.

The following table gives actual changes of pressure data for eight widely separated stations for several days during this period, in order to show that the barometric changes are almost certainly simultaneous and approximately uniform in amount over the Indian monsoon area and are hence apparently not due to the passage across it of waves of low and high pressure. If they were, it would be necessary to assume that the waves were of enormous extent either from west to east or from north to south, and that they travelled at a rate of at least 1,000 miles daily, as the barometric changes to be explained by the advance of these waves occur over the whole of the land area of India almost simultaneously and in periods of less than 24 hours, and there is not, so far as I am aware, any evidence for the existence of such waves in the tropical belt of the atmosphere.

DATE.	ACTUAL BAROMETRIC CHANGE OF 24 HOURS ENDING AT 8 A.M. OF DATE.							
	Bushire.	Aden.	Peshawar.	Sibsagar.	Tavoy.	Colombo.	Minicoy.	Zanzibar.
November 1892, 4th	+ '049	+ '072	+ '086	+ '088	+ '052	+ '020	+ '058	+ '055
" " 11th	+ '104	+ '055	+ '020	+ '064	+ '050	+ '056	+ '062	+ '044
" " 13th	- '088	+ '026 P	- '105	- '054	- '043	- '078	- '044	- '036
" " 21st	- '015	- '015	- '042	- '030	- '019	+ '006	- '020	- '037
December " 5th	- '008	+ '041 P	- '106	- '012	- '007	- '025	- '001	- '024
" " 12th	+ '070	+ '028	+ '025	+ '031	+ '023	+ '050	+ '022	+ '056
" " 16th	+ '010	+ '009	+ '074	+ '022	+ '006	+ '008	+ '034	+ '026
" " 18th	- '066	- '012	- '125	- '047	+ '018	- '004	- '031	- '038
" " 29th	- '034	- '020	- '113	- '029	- '022	- '012	- '001	- '017

The pressure data, it should be noted, are for the months of November and December, months that are usually characterized throughout by fine weather with clear skies and light winds, and the absence of depressions in North-Western and Central India. Hence it is evident that these fairly regular pulsations are a normal feature of the meteorology of the period in India and not the resultant of any actions set up by abnormal conditions.

The last column of the table in chapter III states briefly the character of the pressure changes over India immediately antecedent to the formation and appearance of each storm in Upper India. The following table gives a summary of that information:—

Year.	Total number of storms.	Number of storms which appeared in Upper India during periods of general decrease of pressure.	Number of storms which appeared in Upper India during periods of general increase of pressure.
1878-79	2	1	1
79-80	5	5	0
80-81	2	1	1
81-82	4	3	1

YEAR.	Total number of storms.	Number of storms which appeared in Upper India during periods of general decrease of pressure.	Number of storms which appeared in Upper India during periods of general increase of pressure.
82-83	1	1	0
83-84	3	2	1
84-85	3	2	1
85-86	3	2	1
86-87	2	1	1
87-88	3	2	1
88-89	6	4	2
89-90	3	3	0
90-91	7	4	3
TOTAL 1878-91	44	31	13

This shows that out of a total of 44 storms 31 appeared or formed in the North-Western Frontier districts during periods of general decrease of pressure over the whole Indian area or during the periods of decreasing pressure in the ordinary oscillatory changes of pressure always in progress in the Indian monsoon area. The proportion is so large as to indicate a strong probability that these periods are favourable to the formation of the storms under consideration and also, what is more important, the probability that the storms form within the area of these changes, and hence that in the case of those which advance across the North-West frontier the majority form at no great distance from the frontier, and probably not further west as a rule than Baluchistan.

Place of origin of the primary depressions.—The account of the storms in chapter II has shown that in some cases they undoubtedly formed in India in the area including the South-West Punjab, Sind, Guzerat, West Rajputana and Central India. In the majority of cases they appeared on the North-West Frontier in such a manner as to indicate that they originated either in Baluchistan or in the countries further to the west.

An examination of the Bushire observations also establishes that of the latter storms a proportion (about one in three) passed across or formed in Central Persia. Bushire is, it may be noted, about 1,100 miles west of the Sind frontier. Assuming the average rate of motion of these storms as 350 miles per diem, Bushire is to the west of the Sind frontier at a distance equivalent to three days' march of these storms.

The facts derived from an examination of the Bushire observations are, that the appearance of a primary depression on the north-west frontier is in about one case out of three or four preceded by the following changes at that station :—

1st.—Rapid fall of barometer accompanying the establishment for a brief period of south-east winds.

2nd.—Rapid rise of the barometer following the former and accompanying the setting in again of north-west winds.

3rd.—The winds during this period of large rise of the barometer are usually very much stronger than the normal winds of the season (usually from two to three times as strong).

4th.—Light to heavy rain falls generally during these periods, although sometimes no rain is recorded.

These changes occur three or four days before similar changes are observed in Sind due to the appearance of depressions on the North-West frontier.

It is evident they are produced by the passage of depressions and disturbances, the centres of which advance to the north of Bushire in an easterly direction.

The evidence, hence, establishes that it is probable some of the storms (about one in three or four) which appear on the North-West frontier, are the continuation of depressions which have passed through Central Persia and which may have formed in that area.

The data in Chapter III show that, out of a total number of 55 storms described in Chapter II, 20 probably formed in North-Western India. In the absence of trustworthy data it is not possible to determine with certainty how many of the remaining storms formed in Baluchistan or how many entered Baluchistan from Persia. An examination of the cold weather storm depressions of the past five years indicates that about one out of three storms which pass into India from Baluchistan have previously affected Bushire, and hence probably have advanced through Central Persia.

Total number of cold weather storms, 1878-91.	NUMBER OF COLD WEATHER STORMS IN 1878-91 WHICH ORIGINATED IN		
	Upper or North-West India.	Baluchistan.	West of Baluchistan.
44	18	19	7

The following gives the chief conclusions respecting the place of origin of the cold weather storms based on the examination of the storms of the period 1876-91.

1st.—That a proportion of about one out of two of the cold weather depressions originated in North Western India in an area including Sind, Guzerat, West Rajputana and the South West Punjab.

2nd.—That a considerable proportion formed in and advanced from Baluchistan. One out of every three of these disturbances apparently originated in that area.

3rd.—That a proportion (smaller than in the preceding case) advanced from Central Persia into Baluchistan and thence passed into North-Western India.

The available data are not sufficient to enable a reliable estimate to be formed of the comparative frequency of the origin of storms in these three cases, *viz.* Upper India, Baluchistan and Central Persia. A rough estimate is as 3:2:1. It is evident that the estimate of the relative frequency might vary largely with the definition adopted for "cold weather storms."

As there is undoubted evidence of some of the cold weather storms under discussion having advanced as well-defined depressions from Central Persia, this naturally sug-

gests the question whether these storms may not have been the continuation of storms or depressions, that had previously passed over Central or Southern Europe and the Mediterranean Sea.

The larger cyclonic storms which affect Europe in the winter months appear to belong almost exclusively to two classes.

The greater number of them enter Europe from the Atlantic Ocean, usually crossing the British Isles and thence passing into Continental Europe. They are generally very extensive depressions, usually exceeding one thousand miles in diameter. The depression at the centre frequently exceeds an inch and occasionally one and a half inches.

The following gives the most important features of this class of cyclonic storms of the northern temperate zone:—

- 1st.—The direction of motion is usually from west to east, with more frequently a slight northerly than a slight southerly component.
- 2nd.—The rate of advance of these storms is greater in the United States than in Europe, and greater in winter than in summer.
- 3rd.—In Europe, the depressions in the winter months cross the British Isles and advance in an east to north-east direction into Central or Northern Russia.
- 4th.—The average velocity of advance of these storms in the winter months in Europe is approximately 20 miles per hour.

Cyclonic storms also appear to originate in the Mediterranean Sea between the Island of Sardinia and the mainland or in North Italy. They differ in many respects from the previous class of storms. They are frequently stationary for some days. When they advance from their place of origin, they usually march slowly and irregularly and by very variable tracks, southwards, south-eastwards, eastwards or even north-eastwards. They also generally fill up when they advance eastward over the Mediterranean area and are usually very shallow depressions before they have reached Syria and Asia Minor. An interesting description of this class of storms will be found in "La Nature", No. 1027 for 4th February 1893.

If the cold weather storms of India are the continuation of storms which have entered Europe from the Atlantic and passed into Central Russia, it is evident that they must recurve in Russia and pass thence southwards into Asia Minor or Persia and again recurve, and advance along the easterly course which they invariably appear to follow in passing through Persia, Baluchistan and India. If they adopted this course, they would pass round the normal position of the Central Asia winter anticyclone. I have examined all the available data and cannot find any evidence for it, except a certain correspondence of time in the case of a very small number of storms. And considering the number of storms which affect Europe and Northern India, it would be remarkable if there were not examples of storms in the one area, occurring four to six days later than storms in the other area.

If the cold weather storms of India are occasionally the continuation of storms which have advanced from beyond Central Persia, it appears most probable, taking into consideration their mean track, that they would advance from the Mediterranean area, and hence that their origin might be traced to that of the second class of storms described above. A comparison of the cold weather storms of India with the Mediterranean

storms of Europe, however, shows that they differ in all their more characteristic features. The latter are apparently low-level storms with a large barometric depression and strong cyclonic winds at the earth's surface and are stationary or move slowly and in very variable directions. They usually fill up rapidly if they advance eastwards and are feeble depressions before they reach the east coast of the Mediterranean. It is, of course, possible that they might completely change in these respects during an advance across Syria, Asia Minor and Persia, but it does not appear to be probable.

I have examined various series of records to ascertain whether there are any cases of depressions having advanced eastwards from the Mediterranean across Central Persia during the winter months. The International Charts for the years 1878-82, published by the Washington Weather Bureau, furnish only three examples. The first was a depression which lay over the east of the Mediterranean Sea on the 4th February 1878, and was transferred eastwards during the following four days. The centre was in about Long. 42° E on the 5th, Long. 55° E on the 6th and Long. 60° E on the 7th. A reference to the cold weather storms of 1878 shows that a cold weather storm passed across Northern India between the 9th and 12th February. It was, however, a very feeble storm. It is probable that it was the continuation of the Mediterranean depression. The second case was a depression which formed in the Mediterranean on the 18th of March 1878 and advanced eastwards to about Long. 60° E. No cold weather storm occurred in India during the last ten days of March. The third case was a storm which formed on the 14th February 1881, in the Mediterranean. The centre lay in Long. 25° E and, as is shown by the chart, advanced eastwards during the next three days to about Long. 50° E. In this case also no cold weather storm occurred during the next ten days in Northern India.

I have also examined the daily weather charts published by the French Meteorological office during the past six years, and those published by the English Meteorological office for the years 1889-91-92, and have failed to trace the origin of any of the more important cold weather storms in India during these periods to European depressions. A comparison between the numerous cold weather storms of the past two months (January and February 1893) which have been unusually numerous and severe with the European depressions and storms of the same months as indicated in the charts for these months issued by the English Meteorological office, shows clearly that there was no connection between the two series of storms or depressions. For example, an anticyclone lay over the Mediterranean during the greater part of February 1893, during which month a series of cold weather storms of considerable intensity passed across Northern India and gave unusually heavy snow in the Himalayan area.

The area included in these two series of daily weather charts extends eastwards to the Black Sea and the Palestine Coast of the Mediterranean. Daily weather charts for the Russian Empire are so far as I am aware not published, and hence evidence based on the examination of the available charts named above is by no means conclusive. They however show clearly that depressions have occasionally advanced eastwards from the Mediterranean area into Asia Minor and Syria, but a comparison of the period and character of these depressions with the cold weather storms of India indicates an almost entire absence of all correspondence or connection between the two series of storms.

Hence so far as can be inferred from the available information, cold weather storms

in India are most probably not the continuation of storms or large depressions which have previously affected Europe. It is probable that depressions or storms which have formed in the Mediterranean area may occasionally drift eastwards into Syria, but they apparently fill up as they advance eastwards, and, rarely, if ever, enter Northern India as important cold weather depressions. Hence we have the following inference:—

The cold weather storms of India are not the continuation of European storms, and they originate either in North-Western India or in the plateau areas of Baluchistan or Persia.

Barometric features of the cold weather storms.—One of the most remarkable features of these storms is that a very large proportion of them are double disturbances consisting of a primary and of a secondary depression. The barometric features of the primary and secondary depressions differ very considerably, and hence when they are co-existent, the actual pressure changes and conditions in India are the resultant of two interfering cyclonic systems of different and very varying relative intensities.

The primary disturbances are usually extensive but shallow depressions. If the normal pressure of the period be taken as the standard of reference, the barometric depression due to the primary storms very rarely exceeds three-tenths of an inch and is usually less than two-tenths.

There appears to be a very slight tendency for the amount of the depression to decrease slightly when a cold weather disturbance is drifting through Rajputana and Central India, and for it to increase when it is passing through Bengal.

The shape of these depressions, as determined by the isobnormals, is, roughly speaking, circular, or elliptical of slight eccentricity. It is not possible to establish this inference with certainty.

The secondary depressions usually begin to form when the primaries are entering or passing through Sind or West Rajputana. They vary very largely in intensity, being frequently small and of little importance but are occasionally deep compared with the primary depressions. The following gives barometric data of the two deepest secondary depressions of the past four years (1889-92):—

STORM.	STATION.	Date.	Barometric Change during 24 hours preceding 8 A.M. of date.	Variation from normal pressure of date.
Storm of 29th January to 2nd February 1889.	Sialkot	29th January	—'263	—'172
		30th "	—'197	—'376
		31st "	+ '295	—'103
		1st February	+ '145	+ '029
Storm of 1st to 4th February 1891.	Peshawar	1st "	—'253	—'199
		2nd "	—'327	—'533
		3rd "	+ '445	—'104
		4th "	+ '064	+ '056

STORM.	STATION.	Date.	Barometric Change during 24 hours preced- ing 8 A.M. of date.	Variation from normal pressure of date.
Storm of 1st to 4th February 1891	Dera Ismail Khan	1st February	—184	—169
		2nd "	—375	—545
		3rd "	+452	—105
		4th "	+096	—014

It is easy to determine the general effect of superimposing the shallow primary depression systems on the normal distribution of pressure.

Pressure is, in December, January and February, highest in Upper India and moderate gradients obtain over Northern India. If upon these conditions a shallow primary cyclonic system be superimposed, the result would evidently be to give steeper gradients to the north and slight gradients or approximately uniform pressure to the south. This distribution of pressure is frequently exhibited in North-Western India, when primary depressions are crossing the North-West frontier before secondary depressions have begun to form, and also generally in the case of primary storms which do not give rise to the secondary depressions. A reference to the Daily Weather Reports of the past five years will show many examples. One example of this is given in the chart of the 16th February 1889, plate LXVIII.

Hence the apparent form of the depressions as determined by the actual isobars would be oval with steeper gradients to the north than to the south of the depression, and hence of the form depicted in the plate example above, and would differ considerably from the forms as indicated by the barometric isabnormals.

The resultant of the superimposition of two depression systems, consisting of a primary varying only slightly in intensity during its passage across Northern India and generally of feeble intensity, and of a secondary which may vary from a very feeble to a deep stationary depression, upon the normal distribution stated above, would evidently give rise to an almost infinite variety of forms. The following gives important types of distribution of pressure due to these combinations :

1st.—When the secondary is deep, the primary is almost completely obliterated, its presence being indicated by slight gradients in the intermediate area, and steeper gradients for some distance to the south of the intermediate area. The gradients to the north of the centre of the secondary depressions are usually steep. The charts of the storms of the 23rd to 29th January 1883 and of the 28th January to the 2nd February 1889, (Plates LXIII, LXV and LXVI) show these features very fully. If the isobars due to each of the two interfering depressions or the isabnormals were approximately circular, there would be no difficulty in separating and estimating the abnormals or gradients due to each depression. This has been done in several cases on that assumption with the result of its general confirmation.

2nd.—When the secondary is shallow and is not too far to the north of the primary,

the two systems may combine to give a long trough of low pressure, the axis of which is approximately north and south. As an example may be noted, the storm of February 15th to 31st, 1889, *vide* charts, Plate LXIX. This is the least frequent combination as it requires certain definite relations between the intensity and position of each of the two storms.

3rd.—When the secondary is shallow and its centre is near the hills in the North Punjab, its rising gradients to the south may approximately be equal to those of the falling gradients of the primary and of the season. This combination will give a large area to the north of the centre of the primary depression of approximately uniform pressure. The combination of the gradients of the season with those of the primary storm gives moderate or steepish resultant gradients to the south of the centre of the primary. This distribution of pressure is on the whole of most frequent occurrence during the disturbed periods of the cold weather, its chief features being moderate gradients in the North Punjab, a broad band of nearly uniform pressure in Rajputana or Central India, and steepish gradients at the head of the Peninsula and in Guzerat, Cutch and Lower Sind. A reference to the Daily Weather Reports will show occasional examples in nearly every cold weather season.

These three represent the chief types. But it is evident that the combination of the two systems consisting of a primary and a secondary, differing in intensity, extent and relative position, with the normal distribution of the period, may give rise to a great variety of forms.

An examination of the charts of the past five or six years shows that practically all the more important forms or types of distribution of pressure in the cold weather may be resolved as explained above.

Air motion.—There are many interesting features connected with the air motion accompanying these storms. The air motion at the level of the plains accompanying the primary depressions is almost invariably feeble. It is only when a deep stationary secondary depression forms in the Punjab, that strong stormy winds are experienced in the plains. The following gives an approximate estimate of the strength of the winds in six primary depressions and a comparison with the normal air motion in the same districts:—

PROVINCE.	Mean air movement in miles per hour during six primary depressions, (excluding disturbances.)	Normal air movement in miles per hour.	Percentage variation.
Punjab	27	23	+17
Rajputana	50	37	+35
Central India	48	33	+45
North-Western Provinces	34	30	+13
Bihar	42	32	+31
Central Provinces	37	30	+23
Bengal	34	30	+13

These figures are, of course, approximations as they are the means of the data of
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whole day periods and hence do not correspond exactly with the storm periods, but they give a fair estimate of the general character of the circulation in the primary depression. They show that the storm circulation at the level of the plains differs little from the normal air motion of the period and does not average more than 4 miles per hour over a large part of Northern India. Winds are hence on the average very light, and the cyclonic circulation at the level of the plains feeble and unimportant in the primary depressions.

An equally important feature is that the air circulation at the level of the plains is more or less irregular and does not indicate that regular convergence and indraught to a centre characteristic of a strong and well-defined cyclonic circulation. This is in part due to the frequent interference of the circulations of the primary and secondary systems, but frequently, even in the latter, it is marked by very great irregularities. So many examples have been noted in the history of these storms that it is not necessary to give special data. It is, perhaps, sufficient to refer to the charts of the storms given in Plates LXIII to LXIX, which will show fully the amount of irregularity there is in the air motion at the level of the plains in these cyclonic storms.

Hence in the primary depressions, the observed air motion at the plains stations in Northern India is always feeble and more or less irregular, thus evidencing that in the atmospheric strata near the earth's surface the cyclonic circulation is very imperfectly developed, and that local conditions are sufficient to modify it to a very large extent.

Another point to which some prominence is given in the account of the storms is the changes of wind in the Gangetic Plain and Bengal during the advance of these storms, the relations of which to the storms have been sometimes incorrectly interpreted. Thus in the Gangetic Plain the normal westerly winds are replaced by easterly winds for a brief period during the advance of each storm. These easterly winds are, as a rule, first felt in Upper India, (*i.e.*, in the Punjab and North-Western Provinces,) afterwards in Bihar and finally in Bengal. Their eastward extension accompanies the advance of the storms.

It has been stated that these storms are frequently due to the prevalence of light or moderate sea winds on the Bombay and Bengal Coasts preceding and accompanying the formation of shallow low pressure areas in North-Western India produced by temperature conditions or other causes. A careful examination of the air motion in India during the formation or appearance of the storms in 1876-91 shows that their origin or maintenance cannot be ascribed to sea winds in the lower atmospheric strata. It is true that southerly sea-winds blow into the storm areas when they are passing through Sind and through Chota Nagpur and Lower Bengal. These sea winds are however resultants and not antecedents of the storms.

The following gives a summary of the chief reasons for the conclusion that these storms are not due to sea-winds in the lower atmosphere :—

- 1st.—As a rule, land winds continue on the Bombay and Bengal coasts during the whole or the greater part of the existence of these storms.
- 2nd.—In the great majority of cases the easterly winds accompanying the storms in Northern India are usually first exhibited in the western districts of the Gangetic Plain (*i.e.*, the North-Western Provinces) and extend into Bihar and Bengal with the eastward advance of the storms. They only become sea-winds in the proper sense of the word when the depressions

have advanced into Chota Nagpur and West Bengal and hence so far east that the area of feeble indraught in the eastern quadrants includes the Bengal coast districts and the head of the Bay.

3rd.—These easterly winds are almost invariably light winds.

Hence the important result that the cyclonic circulation at the level of the plains is feeble and somewhat irregular, and that it is not due to a massive humid current from either the Arabian Sea or the Bay of Bengal in the lower atmospheric strata. Any extension of the cyclonic circulation takes place from within outwards, and hence, in the passage of these storms across Northern and Central India, the easterly winds in the Gangetic plain and Bengal are produced by the indraught of the advancing storms. They are almost invariably feeble, and of little importance, and have little or nothing to do with maintaining the cyclonic circulation and contributing to the energy of the storms. The conclusion is important, as it limits the source of the aqueous vapour condensation and rainfall to an upper current of the atmosphere.

Hence not only is the circulation in the primary depressions feeble and irregular, but in so far as it apparently gives rise to winds from the adjacent sea areas, they are mere local winds, resultants of the cyclonic circulation and of no importance for the maintenance of circulation.

In the case of secondary depressions, we have generally the same conditions: but if the fall of pressure has been abnormally great, steep gradients and strong winds may obtain in the Punjab. But even then there is always more or less irregularity, and it is hardly too much to say that the centres of neither the primary nor secondary depressions can ever be obtained either from the wind directions, or the distribution of pressure.

The air motion at the higher level stations stands in marked contrast to that at the plains stations. The exposure of the anemometers at the hill stations varies very greatly. Quetta, Leh and Kailang are all in valleys, and the air motion recorded is always small in amount. The exposure of the instruments is fairly satisfactory and comparatively open at the hill stations of Mufreë, Chakrata, Ranikhet and Mount Abu and the neighbouring plain stations of Lahore, Roorkee, Bareilly and Deesa.

The following gives data for six double depression storms:—

	MEAN WIND VELOCITY IN MILES PER HOUR DURING STORM OF						Mean of six storms.	Normal velocity.	Ratio of storm to normal velocity.
	2nd—7th February 1885.	17th—20th January 1886.	14th—18th February 1886.	10th—16th January 1887.	17th—22nd January 1887.	24th—29th January 1888.			
Murree	14.7	16.7	15.2	9.9	7.4	6.5	11.7	8.2	1.4
Lahore	1.2	4.5	3.6	2.6	2.1	1.2	2.5	2.3	1.1
Chakrata	6.0	7.5	5.8	5.6	3.7	7.2	6.0	5.0	1.2
Roorkee	2.7	2.0	5.0	2.1	1.6	2.3	2.6	2.5	1.0
Ranikhet	8.0	8.0	8.0	8.0	8.0	8.0	8.0	2.0	4.0
Bareilly	2.3	1.7	4.2	3.6	2.2	3.2	2.8	3.4	0.8
Mount Abu	5.2	11.5	7.6	4.4	5.6	4.5	6.5	5.2	1.3
Deesa	7.8	11.3	9.2	9.4	8.4	8.2	9.1	8.8	1.0

Hence these storms almost invariably give rise to stronger winds than usual, not only at the Himalayan stations, but at the isolated hill station of Mount Abu.

At the former stations they show little shift of direction as they are mainly determined by the stationary secondary depressions, but at Mount Abu they shift in the usual manner with the passage of the primary cyclonic systems.

Hence the evidence, so far as it is, is fairly complete in favour of the inferences:—

1st.—That the cyclonic circulation is chiefly developed and maintained in the middle atmospheric strata.

2nd.—That the strength of the circulation is frequently considerable, and in some cases sufficient to give stormy cyclonic winds in the Himalayan mountain area.

3rd.—That these winds are true cyclonic winds.

4th.—Hence, finally the important conclusion that the storms are phenomena not of the lower strata chiefly, but of the middle atmospheric strata certainly, and perhaps of the higher. Their chief development is probably between 10,000 and 25,000 feet. In the case of the storms that I have witnessed in the hills, the condensation and cloud undoubtedly began above 15,000 feet, and in some cases above 20,000 feet; and it was only with the continuance of the storms that the cloud mass apparently descended to lower heights, but other evidence shows that it also extended upwards, so that it undoubtedly increases in thickness in both directions.

It may be added that the facts in support of these inferences would be even more satisfactory and conclusive if it were possible to compare the storm winds with the normal fine weather winds. For the winds during ordinary anticyclonic periods in Northern India are even lighter at the hill stations than in the plains. (*Vide* pages 540—541.)

Hence the air motion accompanying these storms indicates clearly that they are storms of high elevations and higher than the storms of the South-West monsoon proper. The most active portion of the circulation is probably between 10,000 and 25,000 feet, and at the level of the plains the air movement is very feeble and of no importance so far as the maintenance of the indraught and the storm is considered.

Temperature conditions accompanying the storms.—These conditions have been fully discussed in the case of all the more important storms in Chapter II. They differ in degree to some extent according as the storms follow each other rapidly or at long intervals and also according to the snowfall and snow accumulation due to previous storms in the Himalayan and Afghan mountain areas. The following gives a statement of the more prominent features:—

(a) During the interval between the passage of two storms across Northern India, temperature, which is at first more or less below the normal, gradually rises and is generally above it over the whole of Northern India.

The following gives the mean temperature variations in different parts of Northern India during the 48 hours' periods before the appearance of the storms of three years, 1889,

1890 and 1891. The year 1850 was characterized by few storms, and the years 1889 and 1891 by numerous and well-marked storms:—

	Variation from the normal during the 48 hours previous to appearance of cold weather depressions in 1889-90-91, on the north-west frontier.		
	Mean maximum.	Mean minimum.	Mean daily.
	°	°	°
Punjab	-0'4	+2'5	+1'1
Rajputana and Sind	-0'6	+2'7	+1'1
Central India	+2'0	+2'8	+2'4
North-Western Provinces	-0'8	+2'0	+0'6
Bengal	+0'5	+0'5	+0'5
Central Provinces	+1'3	+2'3	+1'8

(2) During the progress of the storms across Northern India, there is a considerable increase of temperature in an area extending 200 to 400 miles in front of the storms, so that the storms appear to advance towards the area of greatest excess of temperature during the preceding 24 hours. In other words, the area of depression has in front of it a warm wave or an area of large excess of temperature, and its advance appears to be constantly directed to this area of excessive temperature. The storm or depression area, as shown on the 8 A.M. weather charts, usually covers the area of greatest excess of temperature during the previous 24 hours. This can only be shown satisfactorily by means of charts. Charts illustrating this feature in the cases of two of the cold weather storms of 1888-89 are given in the annual report on the Meteorology of India for the year 1889.

Immediately in front of the storm areas the maximum and the minimum temperatures are usually both largely in excess. These represent the chief temperature conditions in the area covered by the storm during the next 24 hours. The following gives a few examples from four storms:—

STORM.	STATION.	Date.	VARIATION FROM NORMAL.			Change during previous 24 hours.
			Maximum.	Minimum.	Mean.	
January 1882	Deesa	10th January	+6'3	+16'1	+11'2	+3'5
	Ajmere . . . . .	.....	+5'9	+12'4	+9'2	+6'7
February 1882	Agra	10th February	+12'5	+12'7	+12'6	+7'9
	Delhi . . . . .	.....	+13'2	+8'6	+10'9	+3'0
	Ajmere . . . . .	.....	+12'6	+13'5	+13'1	+5'3

STORM.	STATION.	Date.	VARIATION FROM NORMAL.			Change during previous 24 hours.
			Maximum.	Minimum.	Mean.	
28th January to 2nd February 1889.	Neemuch .	30th January . .	+8.5	+16.2	+12.4	+3.2
	Nowgong .	.....	+11.5	+16.2	+13.9	+5.6
	Jubbulpore .	.....	+12.7	+17.6	+15.2	+5.4
	Sutna .	.....	+13.0	+14.7	+13.9	+8.1
	Khandwa .	.....	+11.5	+15.4	+13.5	+2.0
20th to 25th of February 1889.	Dera Ismail Khan .	22nd February . .	+1.2	+13.9	+7.6	+2.0
	Ajmere .	c c	+6.8	+12.5	+9.7	+7.4

The preceding are given as examples of the large positive temperature variations in front of the storm. A comparison of the whole of the data shows that the approach of the storm makes at first little change in the day temperature. The day conditions are practically unchanged except so far as they are occasionally modified by the shift of wind to south or east, which occurs when the eastern quadrant of the storm is approaching the area. On the other hand a very large increase usually occurs in the night or minimum temperature, which is sometimes 10° to 20° higher than it was on the previous night.

It would hence appear that just in front of the advancing storm is a thin film of cloud, which produces no appreciable effect in diminishing the solar radiation by day. At night, it probably thickens, and is peculiarly effective in arresting terrestrial radiation and hence in diminishing the fall of temperature due to this cause.

The observatory at Allahabad is favourably situated for observing the temperature and other changes due to these storms. The following temperature variation and cloud data for one storm which passed over that station will illustrate the changes of the temperature conditions which occur during cold weather storm, and their relations to the amount of cloud :—

STORM.		VARIATION OF TEMPERATURE FROM THE NORMAL AT				AMOUNT OF CLOUD.			
		5 A.M.	10 A.M.	4 P.M.	10 P.M.	5 A.M.	10 A.M.	4 P.M.	10 P.M.
28th January to 2nd February 1889.		0	0	0	0				
	28th	+4.3	+4.2	+5.8	+8.1	0	2	8	8
	29th	+8.1	+5.8	+6.9	+8.7	2	2	2	1
	30th	+9.3	+1.9	-3.6	+5.8	10	8	2	10
	31st	+8.8	+1.0	-1.8	+2.0	10	2	1	0
	1st	+2.1	-4.7	-6.9	-6.0	0	0	0	0
	2nd	-1.9	-6.6	-5.8	-1.2	0	0	0	2
	3rd	+1.4	-6.4	-6.3	-2.7	8	0	0	0
	4th	-2.4	-8.1	-5.6	-6.5	0	0	0	0
	5th	-6.5	-1.0	-2.9	-3.5	0	0	0	0

Hence we have the following inferences:—

- 1st.—*Each primary storm is preceded by a warm wave. The increased temperature occurs chiefly during the night.*
- 2nd.—*The area of the warm wave precedes the storm centre by about 24 hours or the central storm area on any given day usually covers the area of greatest excess of temperature of the previous day.*
- 3rd.—*These temperature features are almost certainly due chiefly to the effect of a thin veil of cloud in the outskirts of the advancing storm in obstructing terrestrial radiation at night.*
- 4th.—*The increased temperature in front is determined by the advancing storm and is a resultant of actions set up by the storm.*

In the storm area itself, the temperature conditions depend in part upon the amount of cloud and in part upon the occurrence of rainfall. The effect of moderate or thick cloud is to diminish day temperature and to increase night temperature. The effect of rainfall in these storms is of considerable importance. In the first place, the rain falling through a great height cools the air very considerably in its lower descent. It also cools the ground and the combined result is to cause a considerable reduction of the air temperature near the earth's surface for a short period.

A cool wave usually advances across India in the rear of each primary depression. This is one of the most interesting features of these storms. Very clear bright weather obtains in the rear of these storms, but notwithstanding that the solar radiation takes place in an unusually clear atmosphere, the maximum or day temperature, although it rises to some extent after the skies clear up, continues for some days more or less below the normal of the period, whilst the night temperature falls very rapidly, in fact almost as rapidly as it increased in front of the storm. Hence both the day and night temperatures in the rear of the storm area are for some days more or less below the normal. When the day temperature under these conditions is most largely in defect, strong westerly winds prevail, which to some extent prevent the minimum or night temperature in the plains of Northern India falling as low as it would otherwise do if the nights were calm. Hence generally, but not invariably, the day temperature is for a short period of 24 to 72 hours after the passage of these storms more largely in defect than the night temperature.

The following gives some of the most noteworthy variations during the passage of these cool waves during the past four years:—

STATION.	DATE.	VARIATION FROM NORMAL OF			Change of mean temperature of day during the previous 24 hours.	Cloud amount at 8 A.M. of date.
		Maximum of previous 24 hours.	Minimum of previous 24 hours.	Mean of previous 24 hours.		
Roorkee . . .	31st January 1889 . . .	—11·1	—9·3	—10·57	—7·2	0
Ajmere . . .	Ditto . . .	—10·1	—3·8	—7·0	—13·6	0
Peshawar . . .	1st February 1889 . . .	—11·1	—3·5	—7·3	—8·1	9
Indore . . .	8th January 1893 . . .	—17·6	—8·1	—12·9	—11·8	0
Khandwa . . .	Ditto . . .	—17·9	—1·2	—9·6	—9·2	0
Hoshangabad . . .	9th Ditto . . .	—11·3	—4·1	—7·8	—3·7	0

STATION.	DATE.	VARIATION FROM NORMAL OF			Change of mean temperature of day during the previous 24 hours.	Cloud amount at 8 A.M. of date.
		Maximum of previous 24 hours.	Minimum of previous 24 hours.	Mean of previous 24 hours.		
Seoni	9th January 1893	-10°6	-5°5	-8°1	-3°9	0
Rawalpindi	25th Ditto	-14°9	-6°4	-10°7	-2°8	0
Ajmere	Ditto	-18°2	-1°3	-9°8	-13°0	0
Jeypore	Ditto	-20°7	-5°2	-13°0	-10°7	10
Agra	26th Ditto	-13°0	-5°6	-9°3	-2°8	0
Jhansi	Ditto	-10°2	-7°9	-9°1	-13°5	0
Seoni	27th Ditto	-7°9	-10°0	-9°0	-1°5	0
Hazaribagh	28th Ditto	-12°1	-11°2	-11°7	-0°9	0

In plates LXX and LXXI are given charts shewing the progress of the warm and cool waves preceding and accompanying the storm of the 18th to the 23rd January 1891. These illustrate very clearly one important feature of the cool waves, *viz.*, that they do not as a rule affect the Deccan area or South India. They advance across Northern India and along the West Coast, but do not usually surmount the West Ghâts or Satpuras, the mean elevation of which is less than 3,000 feet.

An examination of the whole of the temperature data establishes the following inferences with respect to the cold waves:—

1st.—A broad cold wave follows each cold weather storm.

2nd.—The cooling effect is greatest from 24 to 48 hours after the passage of the storm.

3rd.—The cooling effect advances eastwards across Northern India to Bengal and Burma, but, as a rule, does not appreciably affect the temperature conditions south of the Satpura Range.

4th.—The cooling effect is as a rule more largely exhibited in the night than in the day temperature. Frequently, however, the day temperature is for a short period immediately after the passage of the storms more largely in defect than the night temperature. This is generally the case when the snowfall during the storm in the Himalayas has been heavy, and strong westerly winds set in over Northern India after the passage of the storms. The day temperature, notwithstanding the prevalence of unusually dry clear weather, is frequently reduced from 5° to 10° below the normal for some days after.

5th.—The cooling appears to be dependent chiefly upon the amount of the snowfall and the elevation to which the snowline descends. It is not possible to give exact data, but a comparison of the snowfall data and storm data indicates this to be the general rule.

6th.—The cool waves also appear frequently to advance southwards over the north-east of the Arabian Sea and along the West Bombay coast, sometimes as far south as Karwar and Mangalore, but these waves, apparently rarely, if ever, pass over the West Ghâts, and hence do not affect the West Deccan.

7th.—The reduction of temperature below the normal depends upon a variety of causes, and differs very largely in different storms. The following gives a few of these causes :—

(a) It depends upon the general temperature conditions prevailing antecedent to the storm, and hence to a considerable extent, on the frequency and character of the previous storms of the season.

(b) It depends upon whether the disturbance is a single or a double one. The depression of temperature in the cool wave is usually much larger after a double than a single disturbance.

(c) It appears to depend to a slight extent upon the amount of rain in the plains.

(d) It appears to be mainly dependent upon the amount of the snowfall during the storm, and the height to which the snowfall descends. It is not possible to give exact data, but a comparison of the available snowfall data strongly supports this inference.

8th.—The cooling effect may extend over the whole of Northern India, even when the storm does not advance beyond North-Western India. (A noteworthy example of this was the third storm of February 1889). The cool wave is, hence, not limited to the area passed over by the storm. Its extension, although determined by the storm, is due to other conditions than the extent or intensity of the storm. It is, hence, not due to cyclonic winds of indraught in a particular quadrant of the cyclonic or storm area.

9th.—The cooling effect accompanies the advance of westerly winds in the rear of the storm and after it has broken up. These westerly winds are frequently stronger than what might be termed the cyclonic circulation of the storm proper. The westerly winds set in first on the North-West frontier and gradually extend eastwards over Northern India. They are remarkably dry and cool winds. The cooling effect is directly related to the dryness of the air, being usually greatest when and where the humidity is lowest.

The preceding paragraphs give the chief temperature conditions accompanying the storms in the plains of India. The conditions are in many respects different in the hill districts. The following gives the most noteworthy features :—

1st.—Temperature is usually very considerably in excess before these storms.

The excess of temperature is frequently greatest at Quetta. The following gives data for two storms in illustration :—

STORM.	STATION.	Date.	VARIATION FROM NORMAL OF		Change in preceding 24 hours.
			Maximum temperature of 24 hours preceding 2 A.M. of date.	Minimum temperature of 24 hours previous to 8 A.M. of date.	
Storm of 15th to 18th February 1889.	Quetta	14th February 1889.	+7.8	+12.1	+1.5
	Murree	...	+9.4	+7.1	+3.0

STORM.	STATION.	Date.	VARIATION FROM NORMAL OF		Change in preceding 24 hours.
			Maximum temperature of 24 hours preceding 8 A.M. of date.	Minimum temperature of 24 hours previous to 8 A.M. of date.	
Storm of 16th to 18th January 1891.	Simla	14th February 1889 .	+1°2	+6°9	+0°5
	Ranikhet	...	+7°6	+7°3	+5°4
	Mount Abu	...	+4°1	+3°4	+2°0
	Quetta	15th January 1891 .	+5°4	+9°5	+8°0
	Murree	...	+4°9	+4°7	+6°2
	Simla	...	+2°9	+3°5	-0°1
	Ranikhet	...	+7°3	+6°0	+0°8
	Mount Abu	...	+1°6	+3°9	-0°2

2nd.—During the prevalence of the storms, both the maximum and minimum temperatures decrease steadily, and are usually lowest at the end of the storms when the skies are beginning to clear. There is hence a large reduction in the mean daily temperature and little change in the diurnal range of temperature during these storm periods.

The following gives data for two cases in illustration:—

STORM.	Station.	Date.	28th January.	29th January.	30th January.	31st January.	1st February.
28th January to 2nd February 1889.	Simla	Variation from normal of maximum of previous 24 hours.	+3°1	-1°4	-6°0	-9°3	-20°0
		Variation from normal of minimum of previous 24 hours.	+7°7	+1°7	-4°9	-9°7	-13°1

			2nd January.	3rd January.	4th January.	5th January.	6th January.
2nd to 6th January 1893.	Murree	Variation from normal of maximum of previous 24 hours.	+0°1	-7°7	-16°1	-17°9	-13°1
		Variation from normal of minimum of previous 24 hours.	-2°5	-6°5	-7°7	-8°0	-5°8

In the first case, it will be seen, the storm reduced the day temperature 20° and the night temperature 13°·1. In the second case, the day temperature was reduced 17°·9, and the night temperature only 8°. The two examples show that both the day and night temperatures steadily decreased during the period of the storms.

3rd.—Temperature at the end of the storm is largely below the normal, but usually increases more or less rapidly during the next four or five days. The rate of rise depends chiefly upon the amount of snow lying on the ground at the end of the storm. The following gives temperature variation data for the same stations and storms as the previous:—

STATION.	Variation from normal of	FEBRUARY 1891.					
		2nd.	3rd.	4th.	5th.	6th.	
Simla	Maximum	—13'1	—12'4	—8'2	+0'7	+0'1	
	Minimum	—8'2	—8 8	—3'8	+2 9	+3'1	
	Variation from normal of	JANUARY 1891.					
		7th.	8th.	9th.	10th.	11th.	12th.
Murree	Maximum	—15'2	—15'3	—7'1	—4'1	—1'2	+0'3
	Minimum	—9'8	—9'5	—6'6	—0'9	+4'1	+5'8

In the first case, there were between 2 and 3 feet of snow lying on the ground on the 1st at the end of the storm, and it required about three days to melt it. From the 1st to the 3rd temperature increased very slightly, but from the 3rd to the 6th, both the day and night temperatures increased rapidly. Similarly for the second case. It hence follows that temperature rises at first very slowly at the hill stations, but as soon as the greater part of the snow has melted, it increases with great rapidity.

The above facts indicate clearly the causes of the temperature conditions of these storms at the hill stations. The air temperature during the storms is determined by the temperature of the falling snow. The condensation apparently commences at a moderate elevation, and then extends upwards, as the usual order of precipitation during these storms in the lower ranges is rain, then sleet and finally snow. This appears to be important, as it shows that there is absolutely no tendency for the efficient part of the storm area, the region of active condensation, to descend. There may be extension of the cloud mass in all directions, but the setting up of the ascensional motion tends (as it ought to do by theory), to cause the condensation to occur at higher and not at lower elevations during the progress of the storms.

Cold waves are a frequent feature of cyclonic storms in the United States during the winter months. There are differences of opinion amongst American meteorologists as to the origin of these cold waves.

Cleveland Abbe, in his "Preparatory studies for deductive methods on storm and weather prediction" (page 125), states:—

"During the winter time both Europe and America and Asia are subject to so-called cold waves; it is not likely that these can be due merely to the descent of cold air from above; all the circumstances point to the conclusion that they represent the horizontal flow of immense masses of dry air from northern regions, and that their cooling has been originally due to terrestrial radiation unopposed by solar heat, aqueous vapour, or cloudy skies. They therefore give us no clue as to the temperature of the upper atmosphere;

in fact, they are themselves comparatively shallow and broad masses of cold dry air, whose dryness is as important as their temperature. The advent of the southern limit of such a cold wave is usually preceded in the United States by the appearance of a low barometer to the west of Oregon and Alaska. The flow of air southward is greatly favored by the presence of the immense flat area of Hudson's Bay and the surrounding low lands; the flow of air westward is hindered by the Rocky Mountain Range, and its flow southward is largely determined by the formation of cloud and storm on its south-eastern border."

Ferrel, in his *Popular Treatise on the Winds*, writes as follows of the cold waves in the United States (pages 322-3)—

"It frequently happens in the United States during the winter season that there are large and progressive areas of intense cold which originate mostly in the extreme north-west and progress easterly and south-easterly, frequently as far as the Atlantic Ocean. On account of the great contrast between the temperature of this air and that which it encounters, its easterly progression causes very great and sudden changes of temperature, and hence it is called a "cold wave." Those down in Texas are generally called "Northers." These cold waves have been investigated by Lieutenant Woodruff of the Signal Service for the years 1881-84. He finds that they occur in winter only, and more in January than in any other month; that 86 per cent. originate east of the Rocky Mountains and 14 per cent. come across these mountains, and that by far the greatest number travel across the country from Helena, Montana, to the Atlantic in 32 to 40 hours. He gives instances of temperature changes of 40° to 50° F. in 24 hours. These cold waves are closely connected with, and form a part of, the cyclones which pass over the United States, and an explanation of them has been already partially given in the explanation of the trough-phenomena and weather sequences in the passage of a cyclone over any given place. The whole cold area, however, is not due entirely to the whirling of colder air from higher to lower latitudes on the west side of the cyclone, but also, in a great measure, to the increased terrestrial radiation in winter through the clear air on the clearing-up side of the cyclone, especially on the high plateaus east of the Rocky Mountains."

The phenomena of the cold waves in India suggest that the reduction is due to the descent of air from the plateaux or mountain valleys of Baluchistan and Afghanistan and the Western Himalayas. The temperature of the descending mass of air, when it reaches the plains of Upper India, is mainly determined by the height to which snow has fallen and is lying in these mountain areas. By the act of descent it is, of course, warmed, the elevation of temperature above the freezing point being so much smaller, the lower the height to which the snow line has temporarily descended. After descending it spreads as a comparatively thin stratum over the earth's surface, and it advances over the level ground of Northern and Central India to an extent depending upon the pressure and other conditions which determine the outflow of this cold air. It also advances southwards along the west coast of India. It is, however, generally too shallow to surmount the West Ghâts and pass over the Satpuras, and hence the cooling effect of these dry winds is chiefly shown in Northern and Central India and the West Coast districts as far south as Karwar.

In the more severe double disturbances snow frequently falls in considerable amount

down to a level of 4,000 to 5,000 feet in the Western Himalayas, Afghanistan and Baluchistan. As these areas are at an elevation exceeding 5,000 feet, such snowfalls cause a very large temporary extension of the snow-clad surface to the north and north-west of Upper India. The mean temperature of the mass of air resting over this snow-clad surface at the elevation of the snow line is practically 32° . Air moving downwards to a lower elevation is heated by the action of descent at the rate of 1° F. per 180 feet approximately. Assuming for a concrete case that the snowline is at an elevation of 4,600 feet, and that the air at this elevation (maintained at a nearly constant temperature of 32° by contact with a snow surface) descended to the level of the Punjab plains, the mean elevation of which is about 1,000 feet, the descent of 3,600 feet would increase the temperature of the air 20° or raise its temperature to about 52° F.

The available wind data of the Indus Valley stations show that there is a large flow of air down the numerous passes and across the lower hills of the north-west frontier into Upper India after every cold weather storm, the flow being usually greatest and most prolonged after the most severe storms. The preceding calculation has also shown that if the snowline at the end of a storm were at an elevation of 4,600 feet in that area, the flowing mass of air would, by the act of descent to a level of 1,000 feet, be heated up to 52° , and would give rise to a steady stream of air of that temperature across the Punjab if there were no other actions, such as radiation, etc., affecting and further increasing the temperature of the mass of air. As the mean maximum temperature of the Punjab in January is 67° , the mass of air under the given conditions, and affected only by the act of descent would, if the downflow occurred in that month, be 16° cooler at the hottest period of the day than the normal temperature. The following gives average temperature data of the Punjab for the first 24 hours' period of clear skies and westerly winds in the Punjab after the occurrence of well marked cold weather storms:—

DATE.	Maximum during previous 24 hours.	Variation from normal.	Minimum during previous 24 hours.	Variation from normal.	Cloud.
12th January 1885 . . .	38	—14	37	—5	o
3rd February 1889 . . .	57	—10	38	—4	o
19th January 1891 . . .	56	—11	36	—6	o
4th February 1891 . . .	56	—11	37	—5	o
29th January 1893 . . .	51	—16	37	—5	o

In the case of the first and last storms snow fell down to abnormally low elevations, and the maximum temperature was in these two cases considerably lower than in the remaining three.

It will also be seen that the actual mean maximum temperatures agree closely with that obtained above from the assumption of a descending current from the neighbouring plateaux of Baluchistan and Afghanistan under conditions such as frequently obtain in these cold-weather storms.

It is evident that, under these conditions, the mass of air coming down from the snow-clad areas of North Baluchistan and Afghanistan, may, when it arrives at the level of the plains, be 10° or even 20° below the mean temperature of the air at that level under ordi-

nary conditions, and hence notwithstanding the prevalence of fine clear weather, the solar radiation may not be sufficient to raise the day temperature up to the normal for some days.

The increased deficiency at night is determined by—

1st.—The abnormal dryness of the atmosphere favouring terrestrial radiation.

2nd.—The strength of the winds during the night. If the winds be very light, the cooling effect due to terrestrial radiation will be greater than if light to moderate winds prevail during the night.

All the more important features of these cool waves, *i. e.*, the varying reduction of temperature which follows the passage of these storms across Northern India can, so far as I have investigated, be explained:—

1st.—By the action of the rainfall in reducing temperature in Northern India during the storm and for some time afterwards, whilst the deposited rain is being evaporated and the earth's surface dried to its former or normal condition.

2nd.—By the descent of air from the mountain areas of Baluchistan, Afghanistan and the Himalayas, the temperature of which, on its arrival at the level of the plains, is determined by the height to which the snowline has descended during the storm, and by the advance of this mass of air as a shallow current over the plains of Northern India. The humidity conditions and strength of the flow of air require to be taken in account in explaining the reduction of temperature by day or by night in any area over which this shallow surface current is passing.

Humidity.—The progress of the cold-weather storms across Northern India is accompanied by marked changes in the humidity conditions.

In front of the storm area and in the storm or depression area, the changes in the amount of the aqueous vapour and the humidity at the level of the plains are usually not large except in the districts in which rain is falling. The changes in front of the advancing depression appear to be due to varying combinations of the two following causes:—

- (1) Changes of wind which accompany the advance of the depression across Northern India. Westerly winds, for example, are frequently replaced by easterly winds in the advancing quadrant. As the amount of aqueous vapour depends largely not merely upon the general direction of the wind, but also upon its direction at any station with respect to neighbouring rivers, tanks, or irrigated land, the shift of wind during the approach of a storm to a station may produce considerable local changes in the absolute and relative humidity. Important instances of the occasional great influence of such local conditions have been given by Mr. Blanford, for example, in his memoir on the meteorology of Yarkand.*
- (2) Changes in the amount of cloud. Increasing cloud, for example, diminishes the action of solar radiation at the earth's surface, and hence the amount of evaporation and the manner in which the aqueous vapour is diffused by the action of convection currents.

* Indian Meteorological Memoirs, Vol. I, page 35.

In the depression areas the most important cause of increased absolute and relative humidity is the occurrence of rainfall. Rainfall increases the amount of aqueous vapour in the lower atmosphere in two ways, firstly by evaporation from the surface of the rain drops during their fall to the earth's surface, and, secondly, by the subsequent evaporation from the earth's surface.

The largest and most important changes of humidity and aqueous vapour pressure due to these storms almost invariably occur in the rear of the advancing depressions. The advance of the cold waves and of the westerly winds which set in as the depressions pass across Central and North-Eastern India is almost invariably accompanied by a very large decrease in the amount of vapour present in the air, and of the relative humidity.

This decrease of humidity is usually largest and most rapid at the plain stations and at the lower hill stations in Rajputana, Central India and the Central Provinces. It is also strongly marked at the Himalayan stations when, as occasionally happens, northerly winds set in with the clearing of the skies. Full data have been given in the account of the storms. The following give some of the most noteworthy cases in order to show at a glance the rapidity and magnitude of the hygrometrical changes in the rear of these storms:—

Storm of the 2nd to the 6th March 1881.

STATION.	AQUEOUS VAPOUR PRESSURE AT 10 A.M.			HUMIDITY AT 10 A.M.		
	3rd March.	4th March.	Change.	3rd March.	4th March.	Change.
Ajmere	522	163	—359	73	27	—46
Deesa	601	189	—412	60	20	—40

Storm of the 23rd to the 29th January 1883.

STATION.	AQUEOUS VAPOUR PRESSURE AT 10 A.M.			HUMIDITY AT 10 A.M.		
	24th January.	25th January.	Change.	24th January.	25th January.	Change.
Kurrachee	580	223	—357	74	40	—34

STATION.	AQUEOUS VAPOUR PRESSURE AT 10 A.M.			HUMIDITY AT 10 A.M.		
	25th January 1883.	26th January 1883.	Change.	25th January 1883.	26th January 1883.	Change.
Deesa	517	186	—331	85	36	—49
Mount Abu	22	104	—116	60	37	—23

COLD WEATHER STORMS IN INDIA

Storm of the 5th to the 10th January 1885.

STATION.	AQUEOUS VAPOUR PRESSURE AT 10 A.M.			HUMIDITY AT 10 A.M.		
	7th January 1885.	8th January 1885.	Change.	7th January 1885.	8th January 1885.	Change.
Kurrachee	'704	'213	—'491	%	%	—38
Jacobabad	'329	'042	—'287	69	9	—60

STATION.	AQUEOUS VAPOUR PRESSURE AT 10 A.M.			HUMIDITY AT 10 A.M.		
	8th January.	9th January.	Change.	8th January.	9th January.	Change.
Mount Abu	'421	'034	—'387	%	%	—73
Deesa	'592	'159	—'433	76	34	—42

STATION.	AQUEOUS VAPOUR PRESSURE AT 10 A.M.			HUMIDITY AT 10 A.M.		
	9th January.	10th January.	Change.	9th January.	10th January.	Change.
Agra	'523	'214	—'309	%	%	—40

Storm of the 28th January to the 2nd February 1889.

STATION.	AQUEOUS VAPOUR PRESSURE AT 8 A.M.			HUMIDITY AT 8 A.M.		
	29th January.	30th January.	Change.	29th January.	30th January.	Change.
Kurrachee	'513	'243	—'270	%	%	—45
Jacobabad	'329	'189	—'140	96	63	—33

Storm of the 28th January to the 2nd February 1889—contd.

STATION.	AQUEOUS VAPOUR PRESSURE AT 8 A.M.			HUMIDITY AT 8 A.M.		
	30th January.	31st January.	Change.	30th January.	31st January.	Change.
Mount Abu	'312	'102	—'210	% 100	% 31	—69
Deesa	'394	'176	—'218	% 69	% 42	—27
Sirsa	'336	'235	—'101	% 100	% 78	—22

STATION.	AQUEOUS VAPOUR PRESSURE AT 8 A.M.			HUMIDITY AT 8 A.M.		
	31st January.	1st February.	Change.	31st January.	1st February.	Change.
Rajkot	'372	'141	—'231	% 77	% 26	—51
Indore	'262	'108	—'154	% 58	% 25	—33
Nowgong	'397	'239	—'158	% 96	% 64	—32
Pachmarhi	'164	'082	—'082	% 38	% 18	—20

STATION.	AQUEOUS VAPOUR PRESSURE AT 8 A.M.			HUMIDITY AT 8 A.M.		
	1st February.	2nd February.	Change.	1st February.	2nd February.	Change.
Hazaribagh	'404	'184	—'220	% 91	% 47	—44
Calcutta	'549	'357	—'192	% 93	% 71	—22
Dacca	'553	'391	—'162	% 93	% 71	—22
Saugor Island	'529	'343	—'186	% 79	% 66	—13

Storm of the 1st to the 5th February 1891.

STATION.	AQUEOUS VAPOUR PRESSURE AT 8 A.M.			HUMIDITY AT 8 A.M.		
	1st February.	2nd February.	Change.	1st February.	2nd February.	Change.
Kurrachee	'505	'145	—'360	% 86	% 34	—52
Jacobabad	'394	'150	—'244	% 81	% 45	—36

Storm of the 1st to the 5th February 1891—concluded.

STATION.	AQUEOUS VAPOUR PRESSURE AT 8 A.M.			HUMIDITY AT 8 A.M.		
	2nd February.	3rd February.	Change.	2nd February.	3rd February.	Change.
	"	"	"	%	%	
Neemuch	483	123	—360	91	32	—59
Mount Abu	356	085	—271	96	24	—72

STATION	AQUEOUS VAPOUR PRESSURE AT 8 A.M.			HUMIDITY AT 8 A.M.		
	3rd. February.	4th. February.	Change.	3rd. February.	4th. February.	Change.
	"	"	"	%	%	
Bombay	419	244	—175	62	43	—19
Lucknow	444	197	—247	96	52	—44
Pachmarhi	309	136	—173	62	31	—31

STATION.	AQUEOUS VAPOUR PRESSURE AT 8 A.M.			HUMIDITY AT 8 A.M.		
	4th. February.	5th. February.	Change.	4th. February.	5th. February.	Change.
	"	"	"	%	%	
Calcutta	656	263	—393	95	48	—47
Saugor Island	731	275	—456	90	46	—44

The preceding data show that the amount of aqueous vapour may be reduced in 24 hours to one-third, one-fourth, or in exceptional cases to one-seventh or even one-twelfth of its amount at the commencement of the 24 hours' period.

The changes of humidity conditions due to the advance of cool westerly currents of air across Northern India after the passage of cold weather storms, and of cool northerly currents over Western India and the north-east of the Arabian Sea, are hence frequently very large in amount, and occur with great rapidity. They differ very considerably in character and amount in different cases, depending in part on the character of the storm and in part on the antecedent conditions. The preceding data show some of the most characteristic features, among which the following are the most noteworthy:—

- (1) The reduction in the amount of aqueous vapour is first shown on the north-west frontier, and the effect is transmitted eastwards at a rate practically identical with the advance of the storm, and of the westerly winds in the rear of the storm.

- (2) The changes are frequently as large at the coast stations of Sind and Kattywar and of Bengal as at stations in the interior:
- (3) The changes are sometimes as large in absolute amount at the hill stations of Mount Abu and Pachmarhi as at the neighbouring plain stations.
- (4) The changes at the Himalayan hill stations are usually smaller relatively to the general conditions or the conditions obtaining during the storm than at the low level stations, but they are occasionally very large, more especially when a northerly wind blows down from the higher ranges across these stations.
- (5) The changes are usually small in amount in the greater part of the Deccan and in Southern India during these periods, even when the Bombay and Malabar coast stations have experienced a large decrease due to the southward advance of dry northerly winds along the west coast of India.

The changes of the amount of aqueous vapour after the larger storms are hence so large and marked as to be explicable only by the intrusion of a current of exceedingly dry air, the dryness of which is, in part at least, produced by descent from a high level to a low level. The advance of descending currents of air from Afghanistan and Baluchistan, and the southern face of the Himalayas over Northern India necessary to explain the phenomena of the cool wave is also adequate to explain all the more important hygrometric features noted above.

The following gives a brief summary of the most important hygrometric features of the cold weather storms of Northern India :—

1st.—The variations during the progress of the storms are generally excessive.

2nd.—There is frequently a slight increase in the amount of aqueous vapour and sometimes of the humidity in front of the storms. This appears to be chiefly due to the changes in the wind direction caused by the approach of the storm.

3rd.—There is always a large increase in any district that receives rain during the advance of the storms, and the effect due to this cause is prolonged by the subsequent evaporation from the surface soil.

4th.—There is always a very large decrease in the amount of aqueous vapour in Northern and Central India following the passage of the storms across Central India. This decrease is, as a rule, most rapid and most excessive in Sind, Central and South Rajputana and Central India, where the rainfall due to the storms is usually small in amount.

5th.—The contrast between the humidity conditions in front and rear of the storm, is always more or less strongly marked; and is as marked when the storm advances near the coast of Sind or of Bengal as in the interior of Rajputana or Central India. In these cases the humidity before the advance of the storm is unusually high, in consequence of slight indraught of southerly winds from a sea area.

Cloud.—In the account of the storms, Chapter II, full data have been given of the amount of cloud at stations in the storm areas. A consideration of the whole of the data shows :—

- (1) The formation of cloud occurs chiefly in the eastern and northern quadrants. The cloud canopy frequently extends from four to eight times as far in front of the storm centre as it does in the rear.

- (2) Skies cloud over slowly in front of the storm, the changes from light cirrus to thick nimbus or pallium clouds occurring much as they do in European cyclonic storms.
- (3) The thickness of cloud diminishes very rapidly to the west of the centre and occasionally terminates almost abruptly in a sharp line, beyond which skies are free from cloud and unusually bright and clear.
- (4) In addition to the ordinary development of cloud in the storm area due to the primary depression, similar in character to that observed in European cyclonic storms, there is a special development of cloud in the northern quadrant over the Himalayas.
- (5) The combination of these actions gives a peculiar distribution of cloud in these storms. The mean track of the centre of the storms is through Sind, Central Rajputana, Central India, Chota Nagpur and South Bengal. The amount of cloud is small in districts to the south of the line of advance, moderate in and near the central area and greatest over the Himalayas and the neighbouring plain districts, and hence at some distance from the track of the centre in the northern quadrant.

The following average cloud data for twelve storms, six being double disturbances and six single disturbances, show approximately the general character of the distribution of cloud :—

PROVINCE.	AVERAGE CLOUD AMOUNT.	
	During whole period of six single disturbances in 1886-91.	During whole period of six double disturbances in 1886-91.
Hill Stations, Northern India	5'9	5'9
Punjab	4'2	5'2
North-Western Provinces	3'7	3'9
Sind	3'2	3'
Rajputana	3'0	3'2
Central India	2'3	2'5
Berar	1'3	1'0
Central Provinces	2'3	2'0
Bengal	2'7	2'7
Assam	5'2	5'4

The preceding table shows clearly the comparatively small amount of cloud in Central India and the Central Provinces during these storms, and the large amount in the Punjab and Assam at the foot of the hills, and also over the Himalayan area, where, as might be expected, it is considerably greater than in the plains of Northern India. A noteworthy feature brought out by the preceding data is that the mean cloud amount is not much greater in Upper India during double disturbances than single disturbances.

Rainfall.—During the cold weather period, rain in Northern India occurs almost exclusively during storms or depressions similar to those that have been described in

Chapter II. The rainfall of the cold weather period in any year is hence directly related to the number, intensity, and character of the storms of the period. The distribution of rainfall in the plains depends chiefly upon the following:—

- 1st.—The rainfall occurs chiefly in the eastern and northern quadrants of the primary depression areas. The precipitation is usually small in amount in the central area and to the west and south of the centre.
- 2nd.—The rainfall very frequently accompanies thunderstorms, and is hence irregularly distributed.
- 3rd.—When a primary disturbance gives rise to a secondary depression in the Punjab the rainfall in that area is usually much greater than it is in any other part of Northern India.
- 4th.—When a primary depression is passing through North-Eastern India, there is a tendency to increase of rainfall in the storm area, apparently due to a slight increasing disturbance produced by the approach of the storm to the mountain ranges of East Bengal, Assam and Upper Burma.

Data have been given, in Chapter II, of the rainfall accompanying the more important storms, and of the total rainfall of each cold weather season.

The mean distribution of the rainfall in these storms is indicated by the data of the following table, which gives the average total rainfall in the provinces of Northern and Central India, due to six primary depressions (which did not give rise to secondary depressions) and to six double disturbances, each consisting of a primary and of a well developed secondary:—

PROVINCE.	Total rainfall received during six double cold weather disturbances during the years 1886-91.	Total rainfall received during six single cold weather disturbances during the years 1886-91.
Punjab	Inches. 8'09	Inches. 4'87
Rajputana	1'45	0'20
North-Western Provinces	5'28	3'17
Sind	1'92	0'38
Central India	2'49	0'92
Bihar	4'04	1'39
Bengal	3'00	1'60
Central Provinces	1'05	0'58
Assam	3'84	1'44

The preceding table is based on the rainfall returns of the meteorological observatories only. The data are, however, sufficient in number to indicate the general character of the rainfall distribution in both cases. The second column of the table gives the total average amount received during six single disturbances in Northern and Central India. The total rainfall during these six storms in Sind was less than four-tenths, in Rajputana two-tenths, in the Central Provinces six-tenths, and in Central India nine-tenths of an inch, whereas in the Punjab it was nearly five inches and in the North-Western

Provinces three inches. The returns show in the clearest manner—that the rainfall in the central area of these storms is very small in amount, but that moderate to heavy rain falls on the Indo-Gangetic plain from the Punjab to Assam. The first column gives similar data for six double disturbances. As might be expected, the rainfall was everywhere larger in amount, but the fall in the areas passed over by the central primary depression (*i.e.*, Sind, Rajputana, the Central Provinces and Central India) was from a third to an eighth only of that which was received during the same disturbances in the Punjab. The data also show a slight tendency to increased rainfall in Bengal and Assam.

The chief features of the precipitation are fully shown by the preceding conclusions. It is greater in double than in single disturbances. It is always small in amount in the central area and in the southern and western quadrants of the primary depressions. It occurs chiefly in the north-east and east quadrants, and usually increases in amount northwards to the foot of the hills, where it is probably on the average ten times as large as near the centre of the primary depressions. These facts hence show the very large influence which the Himalayas exert in determining the distribution of the cold weather rainfall during these storms in Northern India.

A very important feature of the precipitation due to these storms is the large snowfall that they give to the Himalayas and Afghan mountains. The snowfall data received previous to the present year 1892-93 were very limited, and not very satisfactory. They, however, show clearly that the precipitation is much greater in the mountains of North Afghanistan than it is in South Afghanistan and Baluchistan, and that it is also greater in the Western Himalayas than in the Afghan mountains. The amount of the snowfall also increases with elevation from the level of the plains up to the elevation of the first snowy ranges. The total snowfall at the higher elevations varies to a very large extent from year to year. In some years, as, for example, 1889, 1891 and 1893, when there were more than the average number of storms, and the majority of them were double disturbances, the snowfall was very large. In stormy cold weather a total fall of 40 to 50 feet in the middle ranges and interior districts of the Western Himalayas is by no means uncommon, and it is probable that at higher elevations it may be even greater. The following gives data for several stations in the Western Himalayas for the three months of January, February and March 1893, received whilst writing this concluding chapter:—

DISTRICT OR AREA.	STATION OR TARSIL.	DEPTH OF SNOWFALL IN			Total fall of period.
		January 1893.	February 1893.	March 1893.	
		Feet.	Feet.	Feet.	Feet.
Kashmir and Punjab Himalayas	Murree	12½	13½	2½	28½
	Dharmasala	10½	10½	4½	25½
	Simla	3½	7½	2½	13½
Kumaun	Chakrata	5½	11½	4½	20½
	Nainital	7½	8½	3	18
	Ranikhet	7	5½	2½	15
	Malla Darma	17	16	7½	40½
	Malla Daupur	18	10	7	35

The fall on the higher elevations of Kumaun, during the winter of 1890-91, was estimated by the local authorities at between 30 and 50 feet. Similarly in the severe winter of 1885 in Kashmir, the total fall was stated to have been at least 40 feet. There is hence fairly satisfactory evidence that in severe winters the snowfall in the Western Himalayas may be as much as 40 or 50 feet, equivalent to a precipitation of 48 to 60 inches of rain. This occurs chiefly during the period of four months, December to March. Considering the extent of area over which it falls, it is evident that this precipitation cannot be due to mere local causes, such as evaporation in the plains of Northern India, and can only be derived from disturbances in a humid current of very considerable intensity. This current is shown by the annual recurrence of the phenomena to be a permanent feature of the circulation of the atmosphere. The amount of the rainfall and snowfall due to it vary largely from year to year, and to a much greater extent than the precipitation due to the lower atmospheric current of the south-west monsoon in India. The following gives the largest and smallest cold weather rainfalls in North-Western India of the past 15 years:—

PROVINCE.	TOTAL RAINFALL, JANUARY TO MARCH, IN			TOTAL RAINFALL, JANUARY TO MARCH, IN			Ratio of greatest to least total rainfall.
	1877.	1891.	1892.	1887.	1890.	1892.	
	Inches.	Inches.	Inches.	Inches.	Inches.	Inches.	
Punjab	6'50	5'94	6'05	1'12	1'51	0'99	6'3
Rajputana	1'00	1'23	1'80	0'38	0'18	0'73	10'0
North-Western Provinces	4'40	3'07	4'12	1'49	0'53	1'24	8'3
Lower Bengal	5'00	6'20	6'74	4'63	1'45	1'00	6'7

Tracks of the cold weather storms.—The tracks of the storms described in this paper have been laid down in two series of charts. The first series, plates LVI to LIX, give the tracks of the storms of each year for the period 1879-91, and the second series, plates LX to LXII, the tracks of the storms distributed according to months. The latter series will be considered first. A reference to the charts of that series will show generally that the storms may be arranged into two classes, according to their tracks:

1st.—Storms the centres of which cross the North-West Frontier north of Jacobabad.

2nd.—Storms the centres of which cross the Sind Frontier south of Jacobabad.

The former storms advance along tracks almost due east, and break up in the neighbourhood of the Himalayas of the South-East Punjab or the North-Western Provinces. As the breadth of India in the parallel of 30° N. which approximately coincides with their mean track is barely 500 miles, these storms have a very brief existence in India, rarely exceeding 48 hours.

These disturbances are usually very shallow, and are far less frequently accompanied with secondary depressions than the second class of storms, the centres of which cross the frontier to the south of Jacobabad. As they are very shallow and cross over an area in which there are usually moderate southerly gradients, the barometric indications of these storms are generally very slight, and the position of the centres can only be approximately determined by consideration of the barometric abnormalities, as well as the isobars. This class of storms is of most frequent occurrence in December. Depres-

sions are much less frequent in these months than in January, February or March, but such as form or appear in Upper India belong almost entirely to this class. The great majority of them give little or no rain in the plains, but are frequently the cause of moderate snow in the hills, more especially in the higher elevations of the Puunjab Himalayas.

They also occur in January, February and March, their frequency decreasing from January to March. As in the two preceding months, these depressions usually give little rain, and they occur most frequently in years when storms of the second class are of rare occurrence. The following is an attempt to classify such storms for the years 1889 to 1893 for which accurate and complete chart data are available :—

MONTH.	YEAR					
	1888-89.	1889-90.	1890-91.	1891-92.	1892-93.	TOTAL.
November	1	0	0	1	0	2
December	3	2	3	1	1	10
January*.	1	1	2	1	1	6
February	0	3	1	1	1	6
March	2	0	0	0	1	3
Total November to March	7	6	6	4	4	27

The following gives a summary of the more important features of this class of the cold weather storms of India :—

- (1) They form in or cross the North-West Frontier between Jacobabad and Dera Ismail Khan.
- (2) These storms are usually very shallow depressions and rarely give rise to secondary depressions, probably not more than 1 in 5 or 6 cases.
- (3) Storms of this class, as a rule, give little or no rain to the plains of Upper India.
- (4) They advance nearly due eastwards and break up in the neighbourhood of the Himalayas in less than 48 hours after their appearance in Sind.
- (5) Their mean rate of motion is approximately 350 miles per diem and appears to be fairly uniform.
- (6) They are most frequent in the earlier cool weather months and decrease in frequency from December to March.

The second class of storms is far more important from an economic point of view than the first. They usually advance across the North-West Frontier between Jacobabad and Karachi, and in the majority of cases march across the whole breadth of Northern India in an east-south-east direction or more exactly S 75° E.

A large proportion of these storms give rise to secondary depressions. A typical example is that of 28th January to 2nd February 1889 which has been fully described, and the chief features of which are shown in the charts (plates LXV to LXVII).

The following gives the average rate of motion of 32 cold weather storms of this class during the three months, January, February and March of the period 1879—91 :—

YEAR.	JANUARY.		FEBRUARY.		MARCH.		PERIOD, JANUARY TO MARCH	
	Number of storms.	Average rate of motion in miles per day.	Number of storms.	Average rate of motion in miles per day.	Number of storms.	Average rate of motion in miles per day.	Total number of storms.	Average rate of motion in miles per day.
1879	...	...	...	...	1	300	1	300
1880	1	220	2	275	...	...	3	257
1881	...	...	...	...	1	450	1	450
1882	1	310	1	385	...	...	2	348
1883	1	370	...	...	...	...	1	370
1884	1	240	1	205	...	...	2	222
1885	2	405	1	340	...	...	3	383
1886	...	...	1	360	1	320	2	340
1887	2	370	...	...	...	...	2	370
1888	2	360	...	...	...	...	2	360
1889	2	360	2	240	...	...	4	300
1890	1	390	2	470	1	370	4	425
1891	1	215	3	315	1	400	5	312
Total or Mean . . .	14	324	13	324	5	369	32	341

The preceding data suggest that the velocity is slightly greater in March than in January and February.

Another well-marked feature is that the storm tracks are slightly more southerly than the mean direction S 75° E in Central India and more easterly in North-East India, thus tending to parallelism with the Himalayan mountain barrier.

Another and probably an important feature is that the more southerly storms tend to advance more quickly than the storms advancing along the normal track. As examples may be noted the most southerly storms of January 1888 and the most southerly storm of March 1891.

The following gives a summary of the chief features of the second class of storms :—

- (1) These storms as a rule enter India across the North-West Frontier between Jacobabad and Karachi, and generally advance over the whole breadth of Northern India.
- (2) The central depression is usually moderate in amount, rarely exceeding '20'.
- (3) This class of storms frequently give rise to secondary depressions. At least two out of three of the larger depressions do so, and one out of two of all the depressions of this class.
- (4) They advance as a rule in an east-by-south direction across the first-half of their track in India, and east-south-east in the second-half.

- (5) The majority of these storms pass across Northern India into Burma, where they either break up, or whence they continue to pass eastwards.
- (6) Their average rate of motion is approximately 350 miles per diem. The rate of motion is slightly greater in March than in January and February.
- (7) Their rate of motion is usually greater in North-East than in North-West India.
- (8) They are of comparatively rare occurrence in November and December.

Annual distribution.—Their law of distribution in different years is a question which can be very imperfectly dealt with in the present paper. It is, however, a subject of very great importance, as an inspection of the track charts for different years (plates LVI to LIX) will show very conspicuous differences from year to year—differences which run parallel with abnormal features in the distribution of the rainfall and in the temperature and humidity conditions of the period.

The account of the cold weather storms, given in the preceding chapter, has established that, in the great majority of years, the characteristic features of each cold weather are maintained throughout the whole period of that cold weather. If storms commence early in any season, (*e.g.*, in December,) the succeeding months of that cold weather have almost invariably a larger number of storms than usual. Similarly, a dry cold weather is one which is unusually dry throughout. What might be termed normal cold weather seasons (*i.e.*, seasons characterized by approximately normal rainfall, and by the normal number of storms occurring fairly regularly throughout the season) are extremely exceptional. The usual rule is, for the cold weather season to be much drier or wetter and much more or less stormy than the normal or mean. Very frequently, an unusually dry cold weather in one year is succeeded by an abnormally damp and stormy one in the next year. Thus the winter of 1888 was very dry, that of 1889 more stormy on the whole than usual, that of 1890 very dry, that of 1891 exceptionally stormy, that of 1892 abnormally dry, and that of 1893 even more exceptionally stormy during the months of January to March than that of 1891.

It is hence evident that the cold weather seasons in India differ very markedly from year to year, and that the characteristics of each season are fairly permanent and persistent throughout the whole of that season.

The following gives some of the more important differences in the distribution and character of the cold weather storms from year to year, deduced from the discussion in Chapter II:—

1st.—The number of depressions differs very largely from one year to another. In one cold weather they may succeed each other rapidly at the rate of two to four in a month, whilst in another they are of comparatively rare occurrence, not more than one or two occurring during the whole season.

2nd.—The character of the storms or disturbances varies largely from year to year. In some years they are almost exclusively shallow primary depressions unaccompanied by secondary depressions, and hence, in such cases, almost rainless storms in the plains. In other years the storms are in the great majority of cases double disturbances consisting of well-developed primary and secondary depressions, and hence each accompanied with more or less general rain in the plains and heavy snow in the hills.

3rd.—A comparison of the track charts for each year will show that there is a marked tendency to slight differences from year to year in the mean track

of these storms, and that the peculiarities in the tracks of any season are fairly persistent throughout the whole season. Thus, in one year, the storms will advance more directly easterly than usual, and along tracks further north than usual. In another year they will cross the frontier further south than usual, and also advance along tracks further to the south, passing into Central or Lower Burma instead of into Upper Burma.

4th.—In consequence of the differences in the character and number of the storms from year to year, the cold weather rainfall in the plains of Northern India and the snowfall in the adjacent mountain areas differ from year to year within very wide limits, exceeding considerably the limits of the range of rainfall during the south-west monsoon in India as measured by the ratio of the maximum to the minimum rainfall of the period.

5th.—Hence, as a further consequence, the mean temperature and humidity conditions of each cold weather, which are very largely determined by the character and number of the cold weather storms, are unusually variable from year to year in Northern India. It is sufficient to compare the temperature variation data of February and March 1892 and 1893, the former of which was characterised by a small number of storms, and the latter by a very large number.

METEOROLOGICAL PROVINCE.	FEBRUARY 1892.			MARCH 1892.		
	VARIATION FROM NORMAL OF			VARIATION FROM NORMAL OF		
	Mean Maximum.	Mean Minimum.	Mean.	Mean Maximum.	Mean Minimum.	Mean.
Punjab	+3.0	+3.0	+3.0	+6.8	+2.3	+4.6
Sind and Rajputana	+3.8	+3.6	+3.8	+5.4	+1.6	+3.5
North-Western Provinces & Oudh	+1.4	+3.0	+2.3	+3.5	+0.5	+2.1
Central India	+2.0	+1.7	+1.9	+2.3	-0.8	+0.8

METEOROLOGICAL PROVINCE.	FEBRUARY 1893.			MARCH 1893.		
	VARIATION FROM NORMAL OF			VARIATION FROM NORMAL OF		
	Mean Maximum.	Mean Minimum.	Mean.	Mean Maximum.	Mean Minimum.	Mean.
Punjab	-10.5	-3.6	-7.1	-6.1	-3.7	-4.8
Sind and Rajputana	-9.2	-2.8	-6.0	-3.7	-1.9	-2.8
North-Western Provinces & Oudh	-9.7	-2.7	-6.2	-7.7	-3.9	-5.8
Central India	-7.8	-3.3	-5.6	-6.9	-3.1	-5.0

It is hence seen that the meteorological features of each cold weather season are, as a rule, very persistent and clearly marked throughout the whole season. The temperature and humidity conditions and the amount and distribution of the rainfall of each cold weather are clearly resultants or effects of the number, intensity and character of the storms of the period. It hence appears to be very desirable to ascertain whether the frequency of these storms depends upon more or less persistent antecedent conditions in India or in the adjacent countries or sea areas.

It is evident that for the consideration of this point it is very important to know whether these storms originate in distant countries to the west of Northern India and from them into and across India in obedience to the general tendency of extra-tropical storms to move eastwards. If these storms originated in Europe, the antecedent conditions would evidently have to be sought there. As, however, the discussion in pages 9 has shown that it is very probable the great majority, if not all, of these storms originate in the area including Upper India, Baluchistan, Afghanistan and Central and Persia, it is probable that the antecedent determining conditions may be present in Indian monsoon area.

A consideration of the chief features of the meteorology of India suggests the following as possible determining antecedents:—

- 1st.—The general strength, extension and prevalence of the previous south-west monsoon (from June to September) and the distribution of the accompanying rainfall.
- 2nd.—The relative strengths of the two currents during this period.
- 3rd.—The character of the changes which determine the retreat of the south-west monsoon humid currents from North-Western India, and more especially the time of that retreat, whether early or late.
- 4th.—The character and extension of the retreating south-west monsoon currents in the Arabian Sea and the Bay of Bengal (more especially the latter), and hence also the distribution and character of the rainfall of the retreating south-west monsoon in the peninsula.
- 5th.—The character of the changes which determine the retreat of the south-west monsoon from Madras and the south of the Bay, and more especially the date of its withdrawal.
- 6th.—The general character of the pressure changes in India during the whole period of retreat and withdrawal of the south-west monsoon from the Indian land and sea areas, as indicative of large differences in the transfer of air between the northern and southern quadrants of the old world or Eastern Hemisphere accompanying the change from hot weather to cold weather conditions in Central and Southern Asia.
- 7th.—The relation between the pressure changes at the level of the plains and hills in Northern India, which probably indicate large and important differences from year to year in the meteorological conditions of the higher easterly current in which these whirls appear to be imbedded and to be carried forward.

Data have been given in the body of the memoir which enable each of these possible

factors to be tested. It is almost certain that each of them exercises some influence, but so far as can be judged, the one of primary importance appears to be the last. The following gives a brief summary of the facts for and against those conditions being assumed to be important determining factors, which could be utilized in forecasting in November or December with reasonable probability of success the general character of the following cold weather :—

1st.—The character and distribution of the cold weather rainfall appear to stand in no direct relation to that of the preceding south-west monsoon rainfall. On the average of a large number of years, the cold weather rainfall in Northern India is above the average to a small extent, when the preceding south-west monsoon rainfall is below it and *vice versa*. The following comparison of the past six years shows clearly that this rule does not hold for single years :—

YEAR.	General character of rainfall of south-west monsoon in Northern India of the year named.	Character of rainfall of following cold weather in Northern India.
1887	In excess in North-West and Central India ; deficient in North-East India.	Deficient in North-West India and the Gangetic Plain ; in excess in Rajputana and Central India, and normal in North-East India.
1888	In excess in the North-Western Provinces, West Bengal and Bihar ; deficient in the Punjab, Rajputana and East-North-East India.	In excess in the Punjab and the North-Western Provinces ; deficient in North-East (except Bihar) and Central India.
1889	In excess in the whole of Northern and Central India except the Punjab plains, Guzerat and Sind, where slightly deficient.	Deficient throughout the whole of Northern and Central India.
1890	In excess in the whole of Northern and Central India except Rajputana, Guzerat and Sind, where deficient.	In excess in the whole of Northern and Central India ; deficient in Assam.
1891	In excess in the North-Western Provinces ; very deficient in North-East India, and deficient in North-West and Central India.	Deficient throughout parts of whole Northern India ; in slight excess in the Rajputana and at a few central stations.
1892	Largely in excess in North-West India and Rajputana ; deficient in North-East India ; generally excessive elsewhere.	In excess throughout the whole country. Excess greatest in North-West India.

Messrs. Hill and Archibald have shown that, on the average of a large number of years, the cold weather rainfall in Northern India varies inversely with that of the preceding south-west monsoon.

The statement of Mr. Hill's conclusion, as given in page 209, Vol. I, Indian Meteorological Memoirs, is that "the winter rains are heaviest when the summer rains are defective, and *vice versa*." In other words, dry winters are usually followed by hot summers, and *vice versa*. Mr. Hill in page 198 states also as a conclusion of his comparison that "the rainfall fluctuates with the sunspot periodicity. The facts pointed out, together with the circumstance that the sunspot period varies greatly in duration, render it impossible to predict the occurrence of droughts and famine years from these relations. The utmost they can do is to afford a rather strong presumption that when the summer rains fall at a time when the sun is free from spots, the succeeding winter rains will be up to or above the average, and that when a dry summer occurs at a time of maximum sunspot, there is a certain probability the winter rains will fail also."

The preceding data hence establish that the rule has many exceptions and that it is of little or no value for the purpose of forecasting the rainfall of a single cold weather season from that of the preceding south-west monsoon. As a single and noteworthy instance of its failure may be noted that of the cold weather of 1892-93. The rainfall of the south-west monsoon period of 1892 was exceptionally heavy in North-Western India, the heaviest on record in the West Punjab, Sind, and some parts of Rajputana. The following cold weather rains (1892-93) were also exceptionally heavy over the whole of Northern and Central India, and almost certainly the heaviest on record in Baluchistan. It is hence evident that there is no simple or direct relation between the distribution and character of the south-west monsoon rains in Northern India during any year, and of the following cold weather rains in the same area.

2nd.—There appears to be no direct relation between the early or late termination of the south-west monsoon rains in North-Western India and the character of the succeeding winter rains. The following table gives the approximate date of the withdrawal of the rain giving current of the south-west monsoon from North-Western India during the eight years, 1885-92, and of the character of the ensuing cold weather rainfall for comparison:—

YEAR.	Date of withdrawal of south-west monsoon from Punjab and Rajputana.	Character of rainfall of following cold weather in Northern India.
1885	5th September	In moderate excess in Northern India, and in largish excess in Berar and the Central Provinces, and in slight defect in Assam.
1886	8th September	Largely in defect in North-Western India, but in excess in North-Eastern India.
1887	18th and 19th September	Deficient in North-Western India and Bihar to a moderate extent. Elsewhere in excess.
1888	20th and 21st September	In excess over North-Western India; in slight to moderate defect in Central India and the greater part of North-Eastern India.
1889	No general fall after the 29th August	General defect throughout the country, greatest in North-Western India.
1890	26th September	In excess in Northern and North-Eastern India excepting Assam.
1891	25th September	Very deficient over the whole of Northern India.
1892	25th September	In excess over the whole of Northern and Central India.

The preceding comparison shows that there is no direct relation between the early or late termination of the south-west monsoon rains in Upper India, and the character of the following cold weather rains. In 1886, and more especially in 1889, the former ceased abnormally early, and the ensuing cold weather rains were largely below the average. On the other hand, they obtained later than usual in 1890, 1891 and 1892. In two of those years the cold weather rains were in excess, but in one (1891-92), they were in defect to a very large extent, and the season was, in fact, one of the driest on record.

3rd.—There appears to be, as shown by the following data, no direct relation between the character of the rainfall of the retreating south-west monsoon rainfall in the Peninsula and that of the following cold weather in Northern India. The following table gives a brief statement of the general character

of the rainfall in Southern India during the months of October to December in each year of the period 1885 to 1892, for comparison with the rainfall of the following cold weather in Northern India :—

YEAR.	Character of rainfall in Southern India during months of October to December of year.	General character of rainfall in ensuing cold weather.
1885	In moderate excess	In moderate excess in Northern India and in largish excess in Berar and the Central Provinces, and in slight defect in Assam.
1886	In moderately large defect in the Carnatic and Ceylon, but in excess in the North Deccan.	Largely in defect in North-Western India, but in excess in North-Eastern India.
1887	Abundant and well distributed	Deficient in North-Western India and Bihar to a moderate extent. Elsewhere in excess.
1888	In moderate defect in the Deccan. In slight excess or normal in Madras.	In excess over North-Western India. In slight to moderate defect in Central India and the greater part of North-Eastern India.
1889	In slight to moderate excess except in the Carnatic where it was considerably (30 per cent.) below normal.	General defect throughout the country, greatest in North-Western India.
1890	In moderate defect in the Deccan, excepting the northern districts and some parts in the centre.	In excess in Northern and North-Eastern India, excepting Assam.
1891	Failed almost entirely in North and Central Madras, slight excess in South Madras.	Very deficient over the whole of Northern India.
1892	Slight excess in North Madras and the Deccan, and failed partially in the southern districts.	In excess over the whole of Northern and Central India.

The data of the preceding table show a slight tendency to excess cold-weather rainfall in Northern India after deficient rainfall in Southern India during the retreating south-west monsoon period, but the exceptions to the rule are so large and frequent that it is of little or no value as an indication.

4th.—The following table, giving the date of the termination of the rains due to the retreating south-west monsoon in Southern India, and the general character of the following cold weather rains in Northern India during eight years, shows that there is no simple or direct relation between the early or late termination of the rains in Southern India and the rainfall of the succeeding cold weather in Northern India :—

YEAR.	Date of withdrawal.	Character of following cold weather rains in Northern India.
1885	24th December	In moderate excess in Northern India and in largish excess in Berar and the Central Provinces and in slight defect in Assam.
1886	13th Ditto	Largely in defect in North-Western India, but in excess in North-Eastern India.
1887	29th Ditto	Deficient in North-Western India and Bihar to a moderate extent.
1888	16th Ditto	In excess over North-Western India. In slight to moderate defect in Central India and the greater part of North-Eastern India.
1889	28th Ditto	General defect throughout the country, greatest in North-Western India.
1890	6th Ditto	In excess in Northern and North-Eastern India, excepting Assam.
1891	27th Ditto	Very deficient over the whole of Northern India.
1892	4th Ditto	In excess over the whole of Northern and Central India.

The mean date of the withdrawal of the retreating south-west monsoon from the south of the Bay, is about the 20th of December.

The preceding data show that there is a tendency to deficient rainfall in Northern India during the cold weather period if the retreating south-west monsoon rains have held longer than usual, and to excess rainfall if they have ceased earlier than usual. The relation is very strongly marked during the six years 1887 to 1892, but the years 1885 and 1886 show that there are failing cases. Hence it can only be inferred that, in about three-cases out of five when the retreating south-west monsoon withdraws earlier than usual, the following cold weather rainfall will be above the normal, and if it is later than usual in withdrawing, the following cold weather rainfall will be more or less below the normal.

A similar examination of the remaining possible antecedent factors determining the character of the cold weather rains given in page 858 shows that, with the following exception, there is no simple relation between any of these conditions and the character of the cold weather rains. In the great majority of cases, as will be shown below, heavier or excessive cold weather rains have accompanied and followed negative vertical pressure anomalies, and deficient rainfall positive vertical pressure anomalies. It may be again noted that the vertical pressure anomalies are the differences between the pressure variations of the hill stations and the neighbouring plain stations. A negative pressure anomaly denotes a deficiency of pressure in the higher as compared with the lower atmospheric strata, and a positive anomaly, an excess of pressure at the higher level stations, and hence probably in the middle atmospheric strata over Northern India.

The subject of these variations of pressure at different elevations of the atmosphere in India is one of great importance, and a paper is in course of preparation dealing with the subject. In the Monthly Reviews for January 1892 and 1893 will be found a brief statement of some noteworthy features of these variations in the cold weather months.

The following table gives data for a comparison of the vertical pressure anomalies during the cold weather seasons of the past fifteen years with the accompanying rainfall:—

YEAR.	Variations of mean pressure of India from normal, October to March.	Vertical pressure anomaly, Northern India, October to March.	Vertical pressure anomaly, Southern India, October to March.	General character of cold weather rainfall in Northern India.
1878-79 . .	— large	+ Moderate	— slight	Scanty.
1879-80 . .	— moderate	— slight	— slight	Generally deficient, excepting North-Eastern India.
1880-81 . .	+ large	— moderate	+ slight	Slightly in excess.
1881-82 . .	— slight	+ slight	+ slight	Slightly deficient, except North-Eastern India.
1882-83 . .	— moderate	— slight	+ slight	Deficient to a moderate extent, except locally in the North-Western Provinces.
1883-84 . .	+ moderate	— slight	— slight	Very deficient, excepting in North-Eastern India.
1884-85 . .	+ large	— large	— slight	Deficient in Upper India, and in large excess in the Central Provinces and Berar.

YEAR.	Variations of mean pressure of India from normal, October to March.	Vertical pressure anomaly, Northern India, October to March.	Vertical pressure anomaly, Southern India, October to March.	General character of cold weather rainfall in Northern India.
1885-86 . .	+ slight	- slight	+ moderate	Excessive.
1886-87 . .	- large	+ slight	+ moderate	Excessive in North-Eastern India, deficient in North-Western India.
1887-88 . .	+ moderate	- slight	- slight	Slightly deficient.
1888-89 . .	+ large	+ slight	+ slight	In moderate excess.
1889-90 . .	- large	+ large	+ moderate	Very deficient.
1890-91 . .	+ moderate	- large	+ large	Excessive.
1891-92 . .	- slight	+ large	+ large	Very deficient.
1892-93 . .	- slight	- large	+ large	Excessive.

In the preceding statement mean pressure variations and vertical pressure anomalies are described as slight when they are less than '01", moderate when they are between '01" and '02", and large when they exceed '02".

In considering the preceding data, it is necessary to bear in mind that the barometric data of several of the hill stations have, until recent years, been in several cases very unsatisfactory during the winter months, due in part to the absence of effective superintendence at that period of the year. Hence the data of the last six years are entitled to greater weight than those of previous years.

The data show conclusively that large vertical pressure anomalies in Northern India are always associated with large variations in the rainfall, negative variations or anomalies accompanying excess rainfall, and positive anomalies deficient rainfall. Also, the larger the pressure anomalies, the larger as a rule are the rainfall variations.

The following table gives mean vertical pressure anomaly and rainfall variation data for the past seven years for comparison :—

YEAR.	MEAN VERTICAL PRESSURE ANOMALY IN INDIA.			MEAN TOTAL VARIATION OF RAINFALL FOR THE PERIOD, JANUARY TO MARCH, IN		
	January.	February.	March.	Punjab.	N.-W. Provinces.	Lower Bengal.
1887	—'028	+ '007	+ '019	—2'09	—0'38	+1'72
1888	—'038	—'009	+ '030	—0'56	—0'02	+0'23
1889	—'003	+ '015	+ '021	+2'28	+1'18	—0'44
1890	+ '047	+ '035	—'021	—0'82	—0'92	—0'88
1891	+ '002	—'045	—'063	+2'81	+1'20	+3'34
1892	+ '038	+ '063	+ '067	—2'14	—0'63	—1'86
1893	—'028	—'062	—'042	+2'92	+2'25	+3'88

The preceding data, more especially those of the four years 1890-93, show very strikingly the relation between the vertical pressure anomalies and the rainfall distribution.

Also, as a rule, the vertical pressure anomalies are generally persistent throughout the whole period from October to March, more especially when they are very marked. The following gives data in illustration:—

YEAR.	MEAN VERTICAL PRESSURE ANOMALY IN INDIA.						
	October.	November.	December.	January.	February.	March.	Mean of period, October to March.
1886-87	+ '017	+ '012	— '005	— '028	+ '007	+ '019	+ '004
1887-88	— '007	+ '008	— '001	— '038	— '009	+ '030	— '003
1888-89	— '020	— '009	0	— '003	+ '015	+ '021	+ '001
1889-90	+ '017	+ '035	+ '032	+ '047	+ '035	— '021	+ '024
1890-91	+ '001	— '015	— '020	+ '002	— '045	— '063	— '023
1891-92	— '013	+ '047	+ '025	+ '038	+ '063	+ '067	+ '038
1892-93	+ '004	+ '002	— '010	— '028	— '062	— '042	— '023

As the vertical pressure anomalies, more especially when large, are not only persistent but antecedent to the cold weather rainfall, they may hence be utilized in November or December to forecast the probable character of the following cold weather rains.

The preceding discussion has hence shown that—

- (1) If the south-west monsoon retreats much earlier than usual from the Bay and Southern India, there is a slight probability that the subsequent cold weather rains will be in excess.
- (2) If the south-west monsoon rains are later than usual in December in retreating from the Bay and Southern India, there is a slight probability that the subsequent cold weather rains will be more or less in defect.
- (3) If the vertical pressure anomalies are persistently negative throughout October to December, it is very probable the cold weather rains (December to March) will be heavier than usual, and the weather stormy on the hills.
- (4) If the vertical pressure anomalies are persistently positive from October to December, it is very probable the following cold weather rains from December to March will be light, and weatherless disturbed, than usual in the hills.
- (5) Continued stormy weather during the cold weather season is almost invariably associated with a local deficiency of pressure in the middle atmospheric strata or with large negative anomalies, and the amount of the precipitation on the whole varies with the magnitude of the anomalies.
- (6) Unusually fine and settled weather in the months of December, January and February is almost invariably associated with excessive pressure in the middle atmospheric strata, or with what may be termed anticyclonic conditions at a high altitude and the deficiency in the rainfall varies directly with the magnitude of the positive anomalies.

In the preceding discussion the more important and characteristic features of these storms have been stated and worked out. They serve as a basis for the following theory of the origin and nature of these storms and for an explanation of their more important features

The first and most important inference respecting these cold weather storms is that they are phenomena of the upper atmospheric currents over Northern India. This follows from the following facts:—

- (a) The cyclonic circulation in these storms is feeble and irregular at the level of the plains. It is strong and well-marked at the Himalayan hill stations.
- (b) The barometric changes are frequently actually as large at the hill stations, elevation 7,000 to 11,000 feet, as at the level of the plains, and hence relatively to the actual pressure greater at those stations than on the plains. If the decrease of pressure in cyclonic storms be a dynamical and not a mere statical effect, this indicates that the chief seat of activity of the cyclones is considerably above the level of the hill stations.
- (c) Observations of clouds in India, more especially at the hill stations, indicate that the lower level of these clouds in the earlier stages is undoubtedly above 15,000 feet and sometimes about 20,000 feet. From cloud observations taken during these storms in the hills at Simla, the cirrus cloud which appears at the commencement, is higher than the highest snows. As the cloud thickens, it also appears to descend. Even after it has formed into a thick dense pallium cloud, the lower limit is seen to be, when it rests on the hills, at elevations generally about 12,000 to 15,000 feet. It is probable that, in the open plains of India, the condensation and formation of cloud occurs at even higher elevations than over the hills, and hence at an elevation of, at least, 12,000 feet, and probably above 15,000 feet.
- (d) The chief precipitation due to these disturbances occurs not in the plains of Northern India, but in the hill districts, the rainfall or snowfall increasing, so far as is at present known, with elevation up to at least 20,000 feet. In this respect, these storms differ entirely from those of the south-west monsoon when the heaviest precipitation occurs in the West Ghats, the Himalayas, and the Assam Hills at elevations between 3,000 and 5,000 feet. It is hence almost certain that this precipitation is due to forced ascensional motion at a high elevation over the Himalayan area, and not to the ordinary or normal cyclonic motion over the whole storm area or in the eastern quadrant of the area.
- (e) These storms, so far as is at present known, never cross the Himalayas. The barometric changes during these storms, and more especially those of the secondary disturbances, are, it is true, frequently as large at Leh, and probably further north, as in the Punjab and at the hill stations of Murree, Simla and Chakrata. There is however no evidence, up to the present time, of either a secondary or primary disturbance having crossed the Himalayas into Thibet as a definite cyclonic disturbance. This hence appears to assign a probable limit to the elevation of the chief seat of the cyclonic motion and action.

It has already been pointed out in Chapter I that the lower air currents in Northern and Central India are probably comparatively shallow currents, and that the direction of these currents is largely determined by the geographical features of the country. During fine weather, the only period when the direction of the ordinary or normal upper air move-

ment can be correctly determined by cloud observations, skies are usually free from cloud. Cirrus observations taken for several years, however, establish that there is an upper atmospheric current of great steadiness. The mean direction of motion of this current, as determined by cloud observations at Calcutta, is S. 83° W., at Allahabad S. 85° W., and at Lahore S. 87° W. This current, it may be noted, is one of the larger features of the atmospheric circulation which have been fully explained by Ferrel.

It is hence probable that the cold weather storms are phenomena of this upper current, that they are generated in this current, and their motion is largely determined by the movement of the mass of air in which they are embedded. The following are the chief reasons why it appears to be probable, that the cold weather storms are large whirls in this upper current, a current which is remarkably steady in direction and probably of considerable velocity:—

1st.—The direction of movement of these storms is very uniform, contrasting strongly in this respect, with the storms of the south-west monsoon period.

2nd.—The mean direction of their advance, S. 75° E., coincides approximately with the mean direction of the advance of the current, N. 85° E., the slight difference being probably, in part at least, due to the action of the Himalayas in modifying their tracks.

3rd.—Their rapid rate of advance, varying from 300 to 500 miles a day, is much greater than that of the south-west monsoon storms, but is probably approximately equal to the average velocity of that portion of the upper current with which they drift eastwards.

4th.—The rate of movement of these storms across India, the rate, as a rule, is fairly constant during each storm, but differs slightly in different storms.

The cold weather cyclonic storms of India appear to resemble the cyclonic storms of Europe and the United States in several important features, which have been fully stated in pages 827-8, and differ in important respects from the storms of the south-west monsoon period in India.

The origin of the secondary depressions in the Panjab appears to be explicable on the assumption that the primary depressions are disturbances in the upper easterly air current of the cold weather over Northern India.

The upper atmospheric current in which these storms appear to form and move is a humid current, as it is undoubtedly in part the continuation of the ascending current over the equatorial belt. It is hence probably strongest and charged with the largest supplies of vapour during the period when the equatorial ascensional movement in the Indian monsoon area is steadiest and strongest, that is, during the north-east monsoon or the cold weather months. During the south-west monsoon period, the ascensional movement over the equatorial belt is more or less suspended by the indraught across the equator and the Indian seas to India, and it is probably very irregular and unsteady during the retreating south-west monsoon period.

The few measurements of the directions of the upper cloud movement, that it has been possible to make at Calcutta and Allahabad during the south-west monsoon, show that the upper current is less steady during that period than in the north-east monsoon.

It is probable that disturbances would be more numerous in this humid current during the cold weather months when it is not only steadiest, and receives the largest supplies

of aqueous vapour by the ascensional motion in the equatorial belt, but also when the temperature conditions are most favourable for formation of cloud and condensation as it advances towards Northern India and the Himalayas.

The equatorial belt in the Old World is not a continuous water expanse, and hence influx of vapour from this belt by ascensional movement into the upper air current to the north of the equator will occur very unequally in different parts. There is a continuous ocean area to the south of Asia, but to the south of Europe and the Mediterranean is the broad belt of the land area of northern and equatorial Africa, and the influx of vapour by ascensional motion from the equatorial belt in that land area will necessarily be small compared with that from the Indian ocean. To this, probably, is due the small rainfall of the cold weather storms in Persia and Baluchistan as compared with that in Northern India.

Hence it is probable that the upper easterly current in Northern India is not only a humid current, but that the current receives its largest supplies of aqueous vapour over Northern India.

When the shallow extensive depressions of the cold weather storms cross the Sind frontier, the indraught in the eastern quadrant draws towards it increasing supplies of vapour. This indraught is shown by the distance to which the cloud extends in front of the advancing depression.

When the primary depressions are crossing Sind and West Rajputana, the southerly humid winds in the eastern quadrant of the advancing depressions are directed toward the Western Himalayas and are forced upwards by that mountain mass. Hence, in virtue of this forced ascensional movement due to geographical conditions in the northern outskirts of the storm area, these storms always give rise to much more cloud in the hills than in the plains, and to much heavier precipitation. This ascensional movement in Upper India, due to the obstructive action of the Western Himalayas, occurs in an area closed in towards the north and west, as well as towards the east, by lofty mountain ranges. A reference to the map of India will at once show the peculiar features of the triangular-shaped area of the Punjab, shut in on all sides, except the south, by more or less lofty mountain ranges and plateaux of great width. The conditions are, in fact, such as make it probable that the forced ascensional movement in the eastern quadrants of these storms when they are crossing Sind and West Rajputana due to the Himalayas might occasionally develop into local whirls and depressions in the North and Central Punjab. If this explanation be correct, the secondary depressions in the Punjab are resultants of this forced ascensional movement on the eastern flank of the Western Himalayas determined in part, if not solely, by the peculiar geographical features of the Punjab.

Taking into consideration these features and the easterly movement of the primary storms which give rise to the forced ascensional movement in the Western Himalayas that probably initiate the secondary whirls in the Northern Punjab, it would follow if this hypothesis be correct that,

- 1st.—The secondary depressions initiated by this forced ascensional movement and intensified by the energy set free by the condensation of vapour and precipitation of rain and snow would vary largely in different primary depressions and depend upon the conditions in the upper current determining the amount of precipitation accompanying the secondary whirl.

2nd.—The eastward movement of the primary whirl would diminish and finally cut off the supply of humid winds that initiate and maintain the secondary whirl; and hence the secondary whirls should commence to fill up when the primary depressions are passing through Central India or South-East Rajputana.

3rd.—The duration of the secondary whirls in any case would hence be conditioned by the advance and rate of advance of the corresponding primaries, and would usually extend in each case from the time the primary entered Sind to the time it was entering Chota Nagpur and Bihar.

4th.—The secondaries might under favourable conditions, depending apparently upon the available supplies of aqueous vapour, develop with extreme rapidity. In such cases they would in consequence of the eastward movement of the primary cutting off the supplies of vapour, fill up even more rapidly than they formed.

5th.—As the primary whirls are features of a higher atmospheric current, the secondary whirls would also originate and be developed in this upper current, and hence the position of the whirl and of its centre would be determined by the highest ranges of the enclosing mountains. The centre of these whirls would hence, as a rule, be in the more northerly districts of the Punjab, and if they advanced at all, their motion would, as a rule, be in an easterly direction and along the edge of the mountain area.

6th.—The movement of the air in the Northern Punjab at the level of the plains would hence be probably chiefly expansional, or ascensional in the earlier stage and the converse in the later stage of the storm, and hence the cyclonic winds at that level would probably be light.

7th.—As the chief indraught would be at a considerable elevation, strong cyclonic winds would probably be experienced in the Western Himalayas.

The history of the storms in Chapter II shows that the phenomena of these secondary depressions described were, as a rule, in complete accordance with what appear to be legitimate inferences from the supposition that the primary depressions are disturbances in an upper humid current over India, the aqueous vapour in which is mainly drawn from the equatorial belt, the influx from which is determined by the distribution of land in that belt. The preceding argument hence appears to establish that *the secondary depressions are due to forced ascensional movement in the eastern quadrants of the primary depressions determined by the Himalayas and that their formation and development are mainly determined by the peculiar geographical features of the Punjab.*

It may also be noted that this hypothesis accounts for the following features:—

1st.—That the precipitation during these secondary whirls is small on the Karakoram mountains and in the Upper Indus Valley, as indicated by the rain and snowfall at Leh, Skardo and other stations in Ladakh and Little Thibet.

2nd.—That the pressure changes at Leh and Kailang are frequently as great as at Murree.

3rd.—That in the cases where these whirls have given practically no rain to the Punjab, heavy snow is known to have fallen in the Kashmir Himalayas and the Hazara and other mountains of the North Punjab.

It may be also noted that both primary and secondary depressions are most numerous in the months of January and February, when it is most probable that the upper current in which they form is strongest and charged with larger supplies of aqueous vapour than at any other season.

When primary depressions originate in Sind or West Rajputana, there is a strong tendency to the formation of shallow secondary depressions, but the conditions are not favourable to their development. The primary storms that form in Sind and West Rajputana are usually very feeble, and the associated secondaries are also feeble. There is also a marked tendency for these feeble secondaries to form in the east or south-east of the Punjab, in which case their combination with the primary gives rise to an elongated belt of low pressure.

The preceding remarks have shown that the cyclonic action accompanying these cold weather disturbances is greatest in Upper India and that the presence of the Western Himalayas gives rise to increased cyclonic motion and barometric disturbance, and hence also larger precipitation than in any other part of Northern or Western India. Similar considerations suggest that the hills of Assam, East Bengal and Upper Burma should exercise a similar influence but to a much smaller extent upon cold weather depressions when advancing through Bengal.

When the primary storms are entering North-Eastern India they are approaching a mass of hills of considerable elevation, the most important of which run north and south. They are dominated by the Eastern Himalayas to the north. The whole group of mountains hence form an acute angle, confining the lower part of the cyclonic circulation. In consequence of these conditions, the winds are very irregular in this area and frequently light airs and calms obtain during the passage of the storms. The chief effect of the actions set up by the mass of mountains in Upper Burma and East Bengal appears to be to give slightly increased cloud and rainfall and occasionally to intensify to some extent the depression when passing through that area.

Several examples of this effect are given in the storms described in Chapter II.

Hence one important result of these storms is to give a very unequal distribution of rainfall in Northern India during the cold weather, the chief features being—

- (1) Precipitation decreasing in amount southwards with distance from the Himalayas:—
- (2) Rainfall largely in excess relatively to the mean rainfall of the whole of Northern India, in Upper India, and slightly in excess in Assam and Burma.

In consequence of the second of these two relations, the intermediate area, including the eastern districts of the North-Western Provinces, should be the area of minimum rainfall in the cold weather.

The discussion in Chapter I has shown that the area defined by the four stations of Gorakhpur, Allahabad, Patna and Darbhanga is characterized by minimum cloud amount and minimum rainfall (*vide* pages 547—549 and 553—554), thus confirming the conclusion obtained from the preceding principle.

The explanation of the origin of the secondary storms and of the relation of these storms to the primaries, hence explains all the more important features of the distribution of the rainfall in the plains of Northern India and the snowfall in the Western Himalayas and Afghan mountain areas, and hence also the peculiar features of the cool dry waves which advance across Northern India after these storms. The explanation of the latter is similar to that advanced by Cleveland Abbe for the cool waves of North America, differing only in the importance it assigns to special geographical conditions in relation to the snowfall to the north and west of North-Western India.

There are many interesting minor features of the storms described in the preceding pages deserving of record. If further experience shows that they are of frequent or of invariable occurrence, they may serve to test the validity of the theories advanced to explain the origin and phenomena of these storms. The following gives a brief statement of a few of these minor features.

The absolute humidity almost invariably decreases to a slight extent at the hill stations in the Western Himalayas when the storms are passing through East Baluchistan and crossing the frontier. The decrease rarely continues for more than 24 hours, and is then followed by a slight to a moderate or large increase depending for its amount upon several causes or actions.

There is frequently if not almost invariably a slight to moderate temporary increase of pressure in the North Punjab when these storms are crossing Baluchistan and approaching the frontier. This local temporary increase of pressure rarely lasts more than 24 hours and is followed by a more or less rapid fall due to the advancing primary and in the majority of cases by the formation of the secondary. A similar large local rise occasionally occurs in Assam and North and East Bengal when these storms are passing through Rajputana and Central India. The increase of pressure in these two cases is so large and occurs so frequently as to indicate to a high degree of probability that it is connected in some manner with the advancing cyclone. It is too large in amount and local in character to be explained by the feeble anti-cyclonic actions immediately outside the cyclone area. If it be a phenomenon of the cyclonic storms it is evidently an action due to the peculiar geographical conditions in these two areas.

Another interesting feature is the transmission of residual depressions slowly eastwards along the Himalayas. These appear to be related to the secondary depressions in the Punjab and not to the corresponding primaries as they advance along the Himalayan area after the secondaries have filled up, and at a much slower rate than the primaries. As there are no observatories over the Central Himalayas between the longitude of Darjeeling and Ranikhet, the data of these residual depressions are very scanty. They occasionally give strong winds at Darjeeling and Gnatong and may be one of the causes of winter snowfall in the Central Himalayas.

These shallow slow moving depressions are very probably what may be termed "residual effects" of the storms. The investigation of cyclonic storms of the transition periods in India has shown that the lower air circulation in a cyclone is much more easily broken up than the higher circulation, and hence that when a cyclonic circulation meets hilly ground the lower portion of the circulation may be disintegrated and light winds prevail at the earth's surface whilst the upper portion of the circulation may continue intact and advance in the same direction as before and may even under favourable circumstances redevelop.

The transmission of the residual depressions eastwards along the edge of the Himalayan area may be explained in a similar manner.

It is not possible to conclude this paper without referring to the relations that exist between the south-west monsoon rains and cold weather rains in Northern India. The most important relation is that first worked out fully in Mr. Blanford's paper "on the connection of the Himalayan snowfall with dry winds and seasons of droughts of India." This is that heavy snow in the Afghan mountains and Himalayas and heavy rain in the plains of Northern India in the cold-weather period are almost invariably followed by a delayed south-west monsoon and frequently by deficient rainfall in that period, and conversely that very light and scanty precipitation in the cold weather in Northern India, and the adjacent mountain areas is usually followed by earlier and heavier monsoon rains than usual. The relation between the south-west monsoon rains and the following cold-weather rains is much more complex. Mr. Hill and Mr. Blanford have shown that an inverse relation exists between the rainfall of the south-west monsoon and succeeding cold weather in Northern India when the average of a large number of years is taken into consideration, that is, that heavy south-west monsoon rains are usually followed by light cold weather precipitation and *vice versa*. The following table gives the variation or the mean rainfall in the Punjab during the fifteen years 1878—92 for the south-west monsoon period and the following cold weather periods.

YEAR.	Variation from normal of rainfall of south-west monsoon period, June to September,	Variation from normal of rainfall of following cold weather period, December to 31st March.
	Inches.	Inches.
1878	+1.37	-2.16
1879	-1.69	-1.76
1880	-1.84	-0.04
1881	+1.37	-0.87
1882	+1.48	-0.99
1883	-4.20	-1.33
1884	+2.34	+0.09
1885	-3.01	+2.92
1886	+1.07	-2.21
1887	+2.63	-0.99
1888	-0.84	+1.80
1889	-1.82	-2.13
1890	+2.56	+2.47
1891	-3.16	-2.19
1892	+7.25	+3.48

In seven out of the fifteen years the rainfall variations of the two periods were the same in character. There were in also seven years in which the south-west monsoon rainfall was more or less in defect, and in five out of these years the rainfall of the following

cold weather was also in defect, and in four cases out of the five considerably in defect. Hence it appears that there is a marked tendency for deficient rainfall during the south-west monsoon in Upper India to be followed by deficient precipitation in the succeeding cold weather. An examination of the rainfall data of the hill stations and of the stations in the Punjab for which there are rainfall data for many years appears to confirm this conclusion strongly. The following two examples are given:—

YEAR.	MOOLTAN.	
	Variation from normal of rainfall of south-west monsoon period, June to September.	Variation from normal of rainfall of following cold-weather period, December to 31st March.
1866	-3.25	-1.12
1870	-3.45	-1.22
1871	-3.45	-0.90

YEAR.	PESHAWAR.	
	Variation from normal of rainfall of south west monsoon period, June to September.	Variation from normal of rainfall of following cold-weather period, December to 31st March.
1864	-3.56	-2.83
1866	-2.36	-4.37
1885	-2.75	+6.07

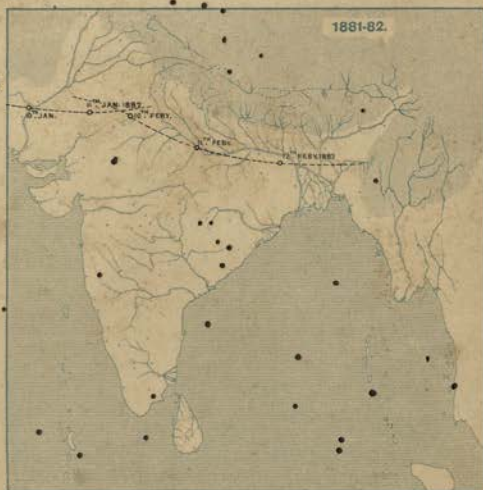
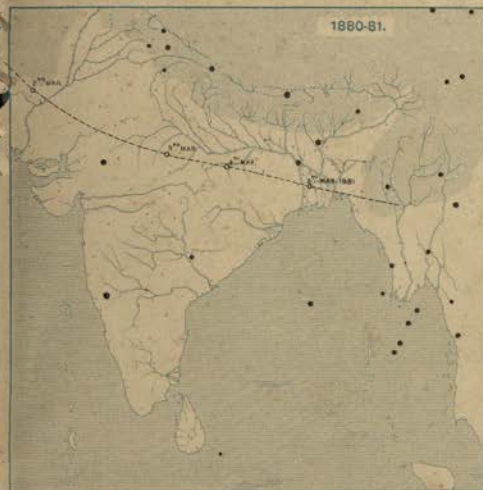
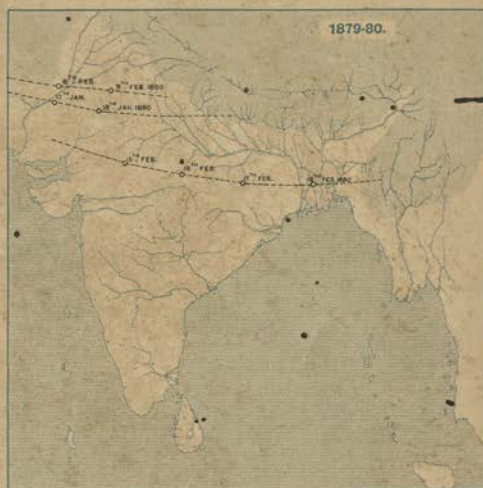
It is the combination of failure of the cold-weather rains following upon failure of the preceding south-west monsoon rains that has given rise to the great majority of droughts and famines in North-Western India. The preceding data give roughly an estimate of the probability of the occurrence of the second failure following the first in Upper India.

The preceding discussion has worked out imperfectly a theory of the cold-weather storms of Northern India. It has shown that they are phenomena of an upper current in Northern India which forms an important part of the general circulation of the earth's atmosphere. So far as can be at present judged, they form in the plateaux and mountain areas of Upper India, Baluchistan, Persia and Afghanistan, and are hence apparently similar to the majority of the winter storms of the United States, which are said to form in the area to the west of the Rocky mountains. It is possible the cold weather storms of India may be merely the redevelopment of shallow depressions travelling eastwards, but there is as yet little or no direct evidence in favour of this supposition. Their development and the peculiar features of the secondary depressions, and the dependent phenomena have been explained by the relations between this upper current over Northern India and the influx of air from equatorial belt, and by the action of the vast mass of the Himalayas and Afghan mountains, and other geographical conditions in modifying the cyclonic motion

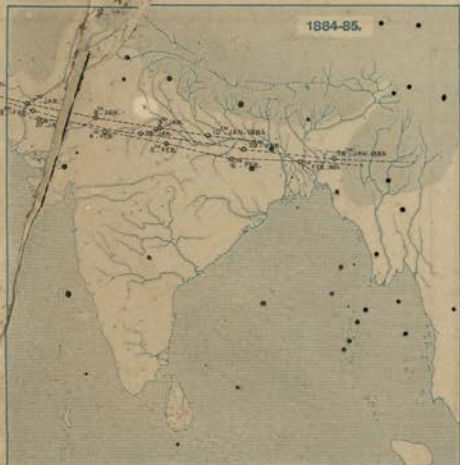
in India, determined originally by the primaries. The phenomena of the warm waves and the dry cool waves which accompany them are to some extent of special effects determined by the conditions of the snowfall in the areas to the north-west and west of India. Their history shows the necessity for an early extension of meteorological observations in the long area between the field of European and of Indian meteorological work.

It is doubtful whether it will be possible to trace the origin of these storms more definitely until international charts for the northern hemisphere, or at least for Europe, North Africa, and Asia are prepared.

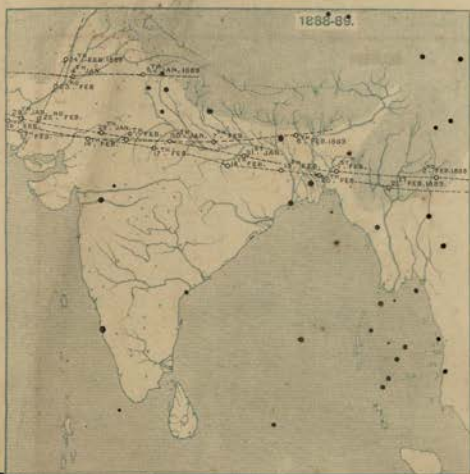
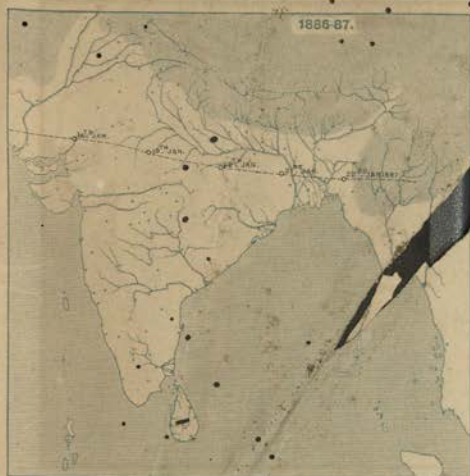
TRACKS OF COLD WEATHER STORMS IN NORTHERN INDIA, 1879-82.



TRACKS OF COLD WEATHER STORMS IN NORTHERN INDIA, 1883-86.



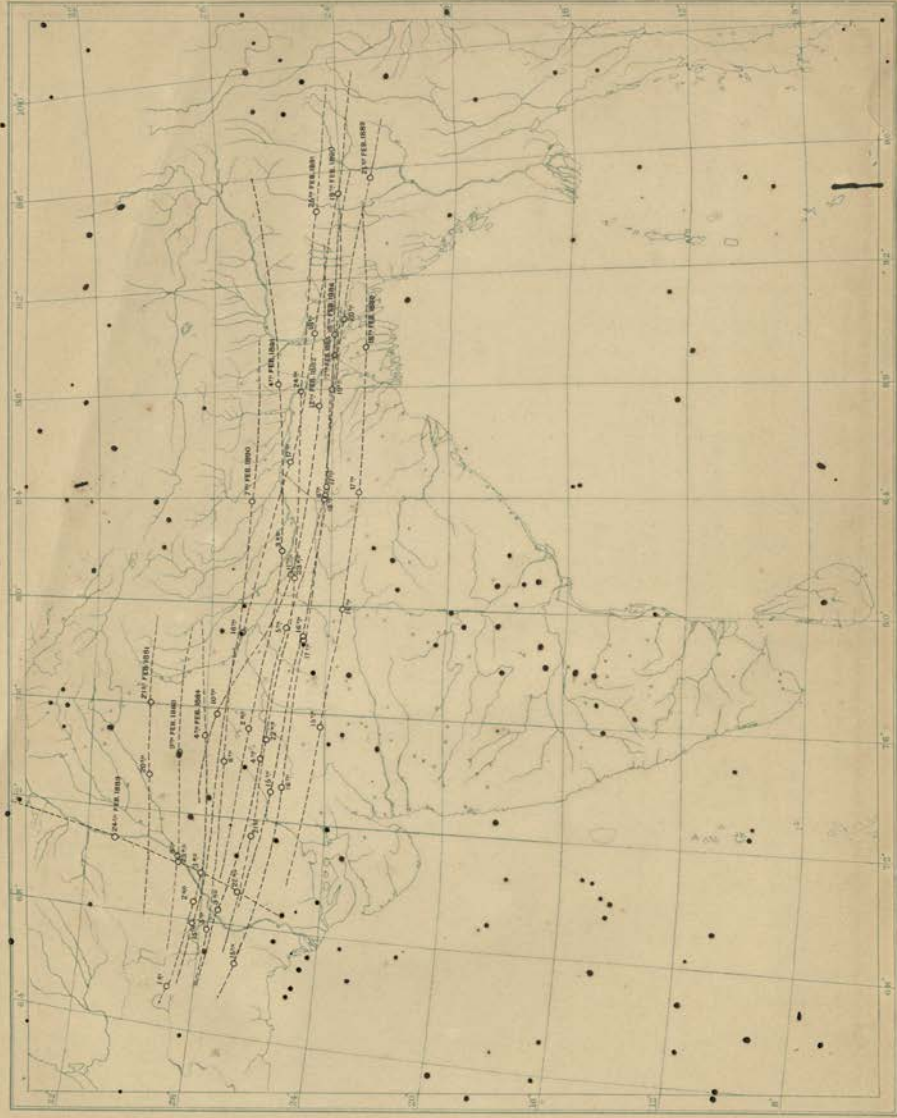
TRACKS OF COLD WEATHER STORMS IN NORTHERN INDIA, 1887-90.



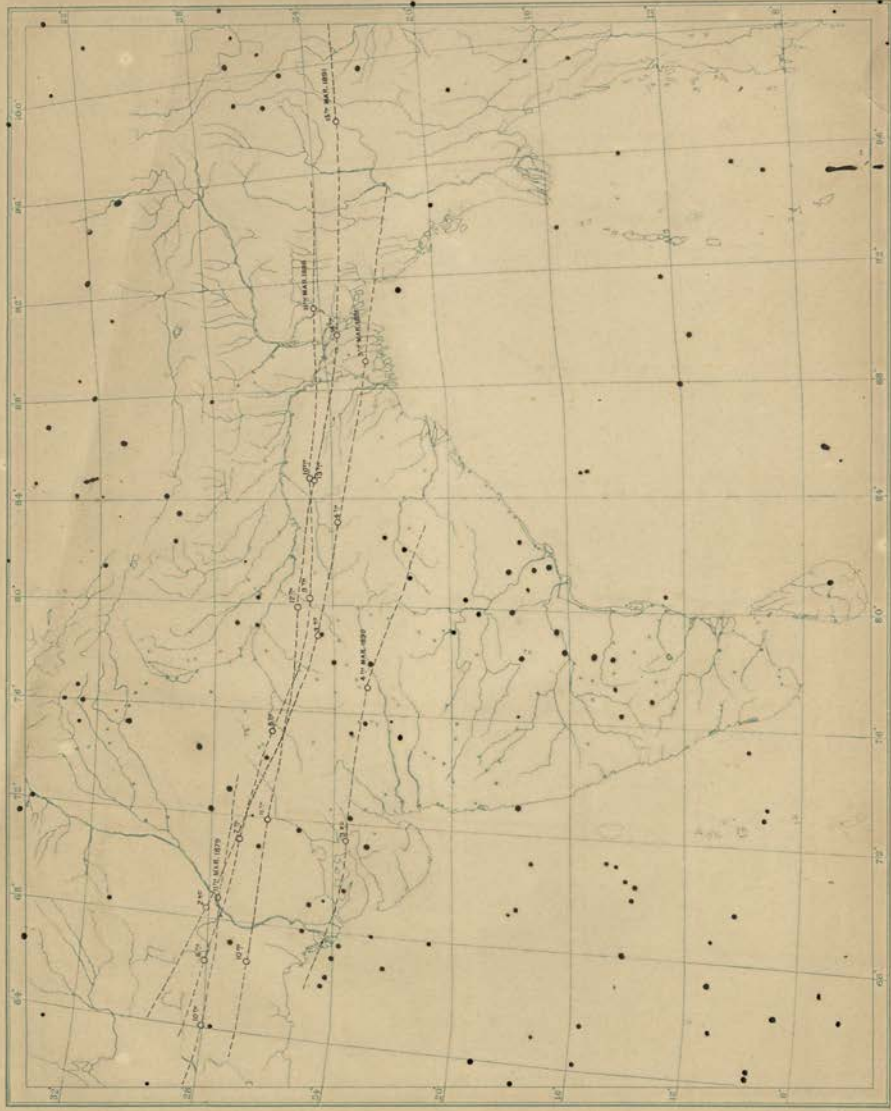
TRACKS OF COLD WEATHER STORMS IN NORTHERN INDIA, 1890-91.



TRACKS OF COLD WEATHER STORMS IN NORTHERN INDIA FOR THE MONTH OF FEB., 1879-91.



TRACKS OF COLD WEATHER STORMS IN NORTHERN INDIA FOR THE MONTH OF MARCH, 1879-81.



10 a.m. 24th JANUARY 1883.



10 a.m. 25th JANUARY 1883.



10 a.m. 26th JANUARY 1883.

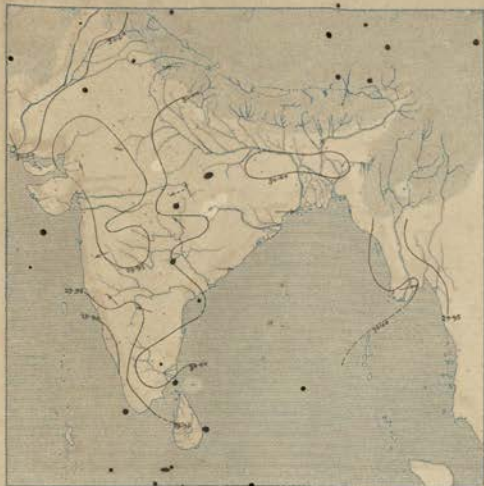


10 a.m. 14th FEBRUARY 1886.



CHARTS SHEWING ACTUAL PRESSURE AND WINDS.

10 a.m. 15th FEBRUARY 1886.



10 a.m. 16th FEBRUARY 1886.



10 a.m. 17th FEBRUARY 1886.

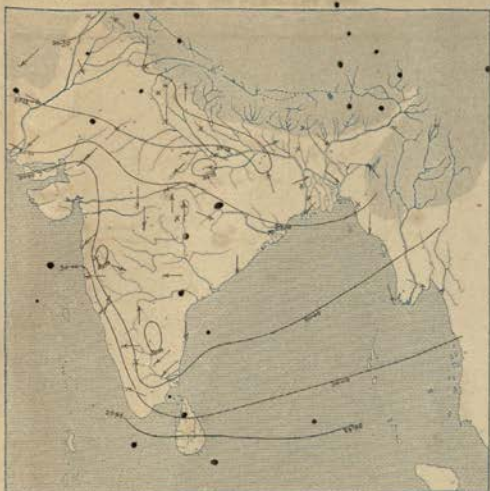


10 a.m. 18th FEBRUARY 1886.

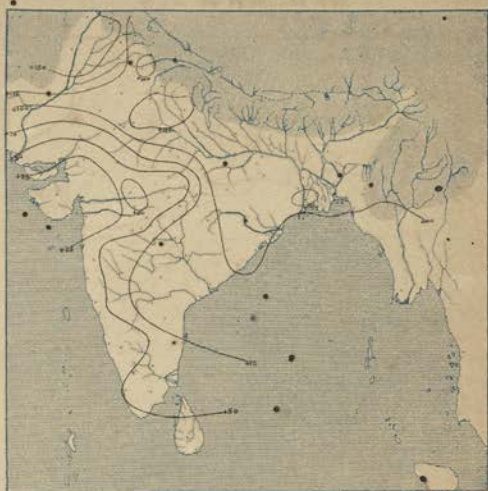


CHARTS SHEWING ACTUAL PRESSURE AND WINDS.

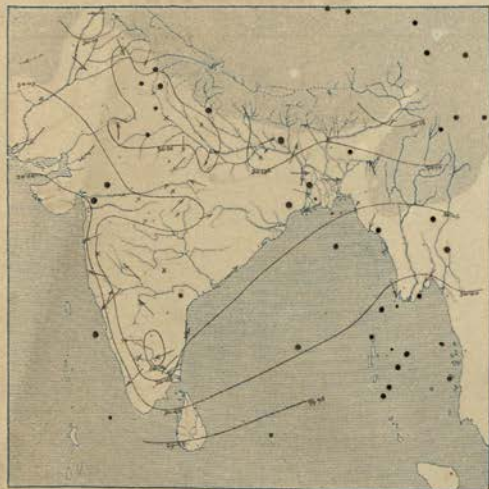
8 a.m. 27th JANUARY 1889.
PRESSURE AND WINDS.



8 a.m. 27th JANUARY 1889.
PRESSURE VARIATION FROM NORMAL.



8 a.m. 28th JANUARY 1889.
PRESSURE AND WINDS.



8 a.m. 28th JANUARY 1889.
PRESSURE VARIATION FROM NORMAL.

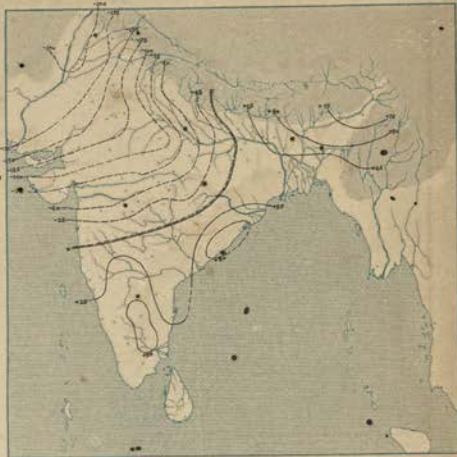


CHARTS SHEWING ACTUAL PRESSURE AND WINDS, AND VARIATION OF PRESSURE
FROM THE NORMAL.

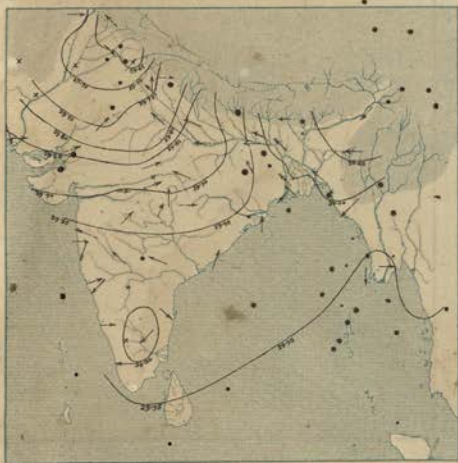
8 a.m. 29th JANUARY 1889.
PRESSURE AND WINDS.



8 a.m. 29th JANUARY 1889.
PRESSURE VARIATION FROM NORMAL.



8 a.m. 30th JANUARY 1889.
PRESSURE AND WINDS.



8 a.m. 30th JANUARY 1889.
PRESSURE VARIATION FROM NORMAL.



CHARTS SHEWING ACTUAL PRESSURE AND WINDS, AND VARIATION OF PRESSURE
FROM THE NORMAL.

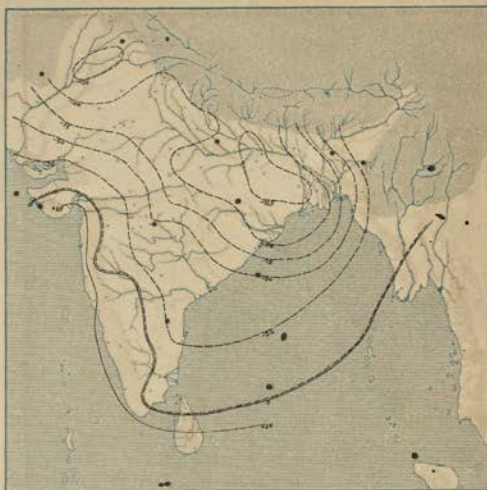
8 a.m. 31st JANUARY 1889.

PRESSURE AND WINDS.



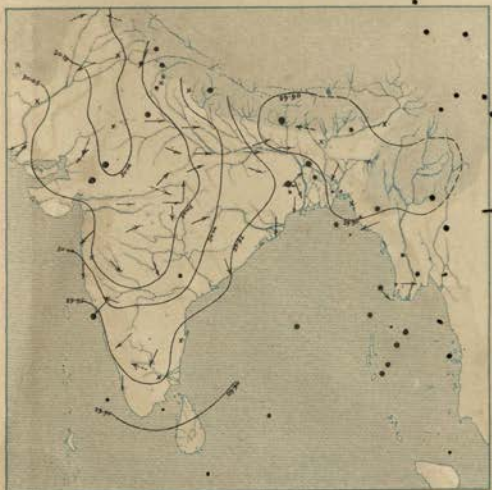
8 a.m. 31st JANUARY 1889.

PRESSURE VARIATION FROM NORMAL.



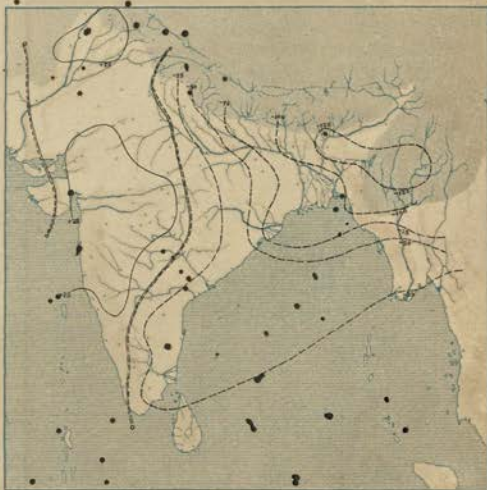
8 a.m. 1st FEBRUARY 1889.

PRESSURE AND WINDS.



8 a.m. 1st FEBRUARY 1889.

PRESSURE VARIATION FROM NORMAL.



CHARTS SHEWING ACTUAL PRESSURE AND WINDS, AND VARIATION OF PRESSURE
FROM THE NORMAL.

8 a.m. 15th FEBRUARY 1889.
PRESSURE AND WINDS.



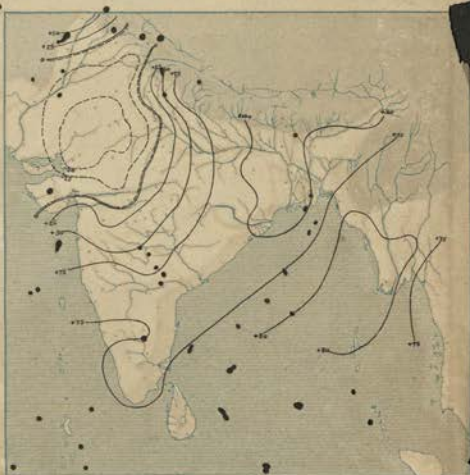
8 a.m. 15th FEBRUARY 1889.
PRESSURE VARIATION FROM NORMAL.



8 a.m. 16th FEBRUARY 1889.
PRESSURE AND WINDS.

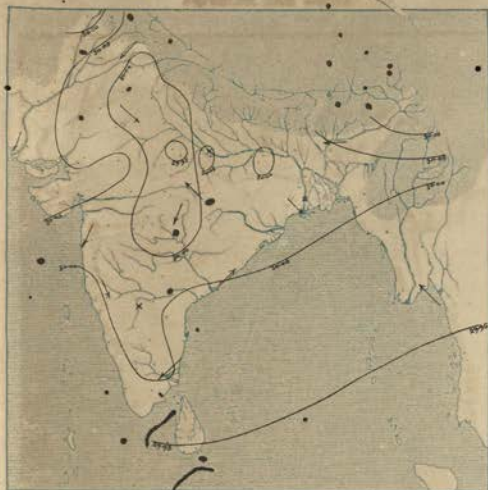


8 a.m. 16th FEBRUARY 1889.
PRESSURE VARIATION FROM NORMAL.

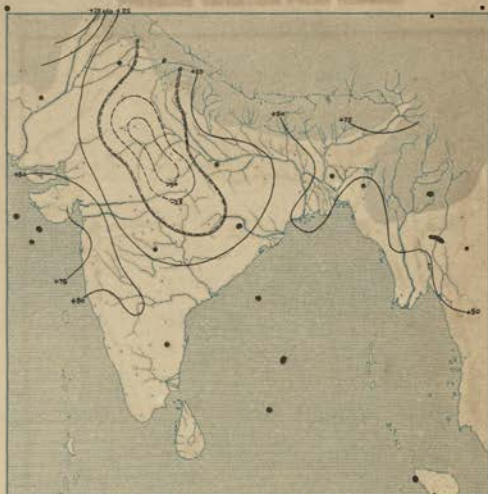


CHARTS SHEWING ACTUAL PRESSURE AND WINDS, AND VARIATION OF PRESSURE
FROM THE NORMAL.

8 a.m. 17th FEBRUARY 1889.
PRESSURE AND WINDS.



8 a.m. 17th FEBRUARY 1889.
PRESSURE VARIATION FROM NORMAL.



8 a.m. 18th FEBRUARY 1889.
PRESSURE AND WINDS.



8 a.m. 18th FEBRUARY 1889.
PRESSURE VARIATION FROM NORMAL.

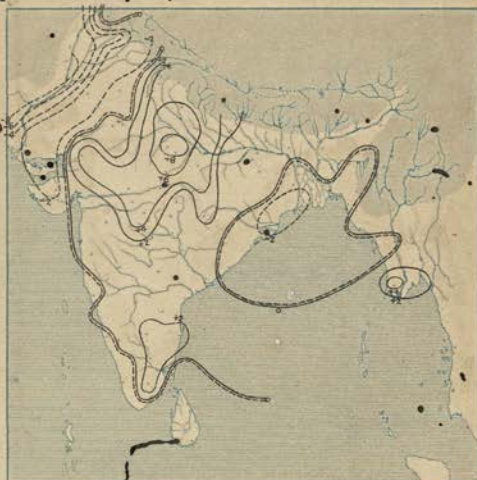


CHARTS SHEWING ACTUAL PRESSURE AND WINDS, AND VARIATION OF PRESSURE
FROM THE NORMAL.

JANUARY 16th, 1891.



JANUARY 17th, 1891.



JANUARY 18th, 1891.



JANUARY 19th, 1891.



CHARTS GIVING THE VARIATIONS OF THE MEAN TEMPERATURE OF THE 24 HOURS PRECEDING
8 a.m. OF DATE FROM THE NORMAL MEAN TEMPERATURE OF THE DATE.



00134430

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